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ABSTRACT The first of 18 papers in this collection is a committee report of a workshop held in Kansas City, Missouri, June 26-27, 1982, to consider instructional uses of computers in pre-college education and what colleges of education should be doing. In "Computer Education and Colleges of Education," J. Philip East provides an overview of the issues involved. Papers submitted by workshop participants prior to the meeting are then presented: "Computer Literate Teachers--a Possible Dream" (James E. Beamer); "Computer Education at Arizona State University" (Gary Bitter); "Computer Related Teaching and Research in the Faculty of Education at the University of Calgary: Achievements, Present Developments and Predictions for the Future" (Ann Brebner); "Graduate Degree Programs in Computer Education for Elementary and Secondary Teachers" (Robert L. Burke); "Computers and Teacher Education: From Cow Trail to Expressway" (George H. Culp); "Computers in the College of Education, University of Illinois" (J. Richard Dennis and Esther Steinberg); "Computer Education for Elementary Schools: A Course for Teachers" (J. Philip East); "The Challenge of Computer Education to Teacher Education--An Australian Perspective" (Graham Ferres); "Computing and Education at the University of Maryland" (James T. Fey and Linda P. Rosen); "An Undergraduate Minor and Graduate Program in Computers in Education" (Susan Friel and Nancy Roberts); "Implementing a Program to Train (Retrain) Secondary Teachers--A Cooperative Effort between Education and Computer Science at Towson State University" (Doris Keefe Lidtke); "Computerizing the Teacher at North Texas State University" (James L. Poirot and James J. Muro); "Computers in Education at the University of Colorado--Boulder" (Marc Swadener); "Computing and Education at Teachers College" (Robert P. Taylor); "Teacher-Education Curriculum for the 80's" (Barbara B. Wright and Richard C. Forcier); and "Computers for Teachers: Activities at the University of Michigan School of Education" (Karl L. Zinn and Carl F. Berger). (LMM)

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TOPICS

Computer Education For Colleges of Education

U.S. DEPARTMENT OF EDUCATION
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Education Board
Special Interest Group on Computer Science Education
Special Interest Group on Computer Uses in Education

January 1983

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COMPUTERS IN PRE-COLLEGE EDUCATION:
WHAT COLLEGES OF EDUCATION SHOULD BE DOING

Report of a Workshop held in Kansas City, Missouri
June 26-27, 1982

Introduction

The ACM Elementary and Secondary Schools Subcommittee is concerned with all aspects of instructional use of computers at the pre-college level and with the related teacher education. For the academic year 1981-82 ACM-ESSS set as its major goal the exploration of what Colleges of Education are doing with respect to the computer education problem and to make recommendations.

A number of people were asked to write papers describing what their Colleges of Education and/or Universities are doing. After these papers were reviewed and revised, the authors were invited to a two day workshop. A list of workshop participants is given in the introduction to this document. This paper is a summary of the ideas presented and recommendations emerging from the workshop.

The paper has two main audiences:

1. ACM members and other people who approach the field of computers in pre-college education from a "Computer Scientist" point of view. These are people whose knowledge of computer science is strong relative to their formal knowledge and experience in pre-college education or teacher training.

2. College of Education faculty, school personnel, and others who approach the field of computers in pre-college education from a "Teacher Education" point of view. These are people whose knowledge and experience in pre-college education or teacher training is strong relative to their formal knowledge and experience in the field of computer science.

The Problem

The existence of the relatively inexpensive microcomputer has created a situation within pre-college education in which the historic objection to computer use, the high cost of hardware, in no longer valid. Large numbers of computers are being purchased or donated for use in public school classrooms. As a result, more and more teachers and administrators who have had little training and experience with computers are involved in making computer-related curriculum decisions.

The magnitude of this problem is difficult to comprehend. There are about 2 million pre-college teachers in the United States alone. Tens of thousands more are graduating each year and beginning their first teaching assignments.

Though Colleges of Education have for many years dealt with materials and media in a variety of ways, computers have not been included or have at best been tangentially touched. Teachers well qualified to teach computer science at the pre-college level are virtually non-existent, and even those well trained to utilize computing in fields other than computer science are rare. Computer scientists know that a student may take several years of computer and information science course work, and just begin to become competent in the field. Providing effective training in computing to pre-college teachers is a complex, important problem.

The two day workshop divided the computers in education problem into four major components. Participants worked in groups and came together as a whole to discuss the following areas:

1. Pre-service training in computers in education.
2. In-service training in computers in education.
3. Graduate programs in computers in education.
4. Research in computers in education.

This paper will summarize the work of each of the four groups.

Pre-service Training in Computers in Education

This area may be divided into the pre-service training of the specialist (teachers of computer science) and the pre-service training of the non-specialist. The case of the specialist is somewhat easier since it is similar in concept to training in other related disciplines. The student would take appropriate courses in computer science and education as established by mutual agreement of the two academic units.

There are two immediate difficulties. First, most computer science departments are overburdened by students already. Many are rapidly raising their standards to cut down the number of majors and others enrolled in advanced undergraduate major's courses. Second, few states recognize computer science as a certifiable area for teachers. Thus teachers must satisfy requirements to teach in some discipline such as business or math in addition to preparing themselves in computer science.

There are two additional important considerations. In long-established disciplines such as mathematics education, a number of courses have been developed especially to meet the needs of pre-college teachers. Currently, computer science departments lack the resources to develop special courses just for teachers. A second consideration is that of computer science methods courses. Should these be offered through the computer science department, the College of Education, or via a team teaching approach? Likely this will depend upon the local situation, but close cooperation between the two teaching units is essential.

The problem of the non-specialist is somewhat more complex. Computer technology is increasingly a topic and tool of instruction at virtually all levels and in virtually all academic areas. If the students now in pre-service training are not equipped to deal with the issues of computers in education, they will have received less than a complete educational experience. These individuals, in their careers, will be required to make decisions regarding the use of computers in schools, and will not have the proper background to make such decisions.

As a result, it is imperative that all Colleges of Education provide all pre-service teachers with a certain minimal background in computers in education. This includes at least the following:

How computers can be used in instruction.
When it is appropriate to use computers in instruction.
Effects of computers on curriculum content and upon the process of instruction/learning.
The nature of current and near-term-future hardware, software, and computer-related educational materials.
Goals for computers in education.

A two-staged approach is recommended for integrating computer education into the curriculum. First, all pre-service teachers should take an introductory course. Two ways to do this are:

1. Make use of existing computer science courses such as a computer literacy course or a computers in society course. The description of such a course has been widely discussed in the literature (see, for example [1] and other articles referenced in this publication). The course typically covers the following material:

   What computers are and how they work.
   A brief history of computers and technology.
   An introduction to programming.
   A survey of the application of computers in society.
   A discussion of social issues in computing.

2. Develop a special course to be offered either through the computer science department or the College of Education. It would be a teacher-oriented version of the computer literacy course discussed above.

Pre-service teachers completing such a course should have increased (if somewhat superficial) knowledge of how computers work and what they can and cannot do, an ability to intelligently discuss the application of a computer when it arises in a non-technical context, and a prerequisite knowledge for the more serious study of computers in education. It should be recognized that the need for such a course is temporal and will disappear as adequate instruction in this area is introduced at the pre-college level so that students entering college will have such a background.

The second stage, built upon a uniform background described above, is instruction regarding the computer as a tool for teaching and learning. Here it is highly recommended that the material be integrated into existing courses rather than having new courses created. Besides the obvious advantage of not expanding requirements, it is felt that this approach will provide an environment in which pre-service teacher will actually be using the material which will in turn have a much stronger impact. Further it should be noted that this approach will require that the instructors need only be familiar with applications in their particular areas rather than applications in all content areas at all levels.

Within the program of instruction the student would become aware of when computer related materials are appropriate and how they are evaluated and selected. In addition, emphasis must be placed on ways in which computer related materials can change instruction. For example, time might be spent in the courses dealing with writing, showing how a word processing system could be used to overcome a great deal of drudgery and instead emphasize creativity. As another example, time might be spent in a course dealing with the teaching of mathematics showing how a graphics system can be used to change theoretical results into visual demonstrations.

Specifically, each student completing this segment of instruction would be expected to know, for his or her area and level, what systems exist, what kinds of application programs exist, and what application packages such as word processing, data base systems, and programmed instruction, exist. In addition to knowing about such material the student would be expected to have had experience in the use of such systems.

To implement this a number of resources will be necessary. A sufficient number of primary machines or work stations must be available, a wide variety of software with appropriate documentation must be available, and a wide variety of journals, magazines and software catalogs must be available. In addition there must be some secondary systems, different from the primary one, available to demonstrate different approaches and to show the need to adapt materials from one system to another. For such a program to work there must be adequate personnel dedicated to manage the resources, and, of course, the program of instruction requires a knowledgeable faculty.

To begin the implementation of such a program it is suggested that first an individual be given appropriate release time to plan the computer education effort and to begin building the resource center including equipment, software and reference materials. Next would come the process of educating the rest of the faculty about the needs of computers in education and the actual use of computing in the various content disciplines. In doing this it would be well to call upon colleagues who are already involved with computer in these areas. It is also suggested that the process begin with the revision of one course and the careful monitoring of its progress as other courses are implemented. As an example, for elementary school teachers, a required writing course or a required math course might be selected.

In-service Training in Computers in Education

While pre-service training as described in the previous section works toward providing a long term solution to adequate background in computers in education, there is much need to update current teachers through in-service programs. This includes all levels through the Colleges of Education themselves.

The usual goals for instructional use of computers in pre-college education call for computer literacy for all students, computer-assisted learning when it is educationally and economically sound, and more advanced computer-education opportunities for limited numbers of high school students. If these goals are to be accomplished at an adequate level, eventually all teachers will need to have a reasonable level of computers-in-education knowledge. This should approximate that recommended for pre-service teachers.

By its very nature, however, the instruction for in-service teachers must take somewhat different lines. Some idea of the range that in-service programs must address can be obtained by considering the types of audiences that might be addressed:

1. All teachers and teacher educators.
2. Computer science teachers and computer science methods educators.
3. Subject teachers and subject methods educators.
4. Computer literacy teachers.
5. Teachers/developers of computer-based materials.

These groups will have different needs and require different approaches as well as different depth of instruction.

The role of Colleges of Education in the in-service area for pre-college educators will be to help provide resources and resource people to conduct appropriate training. The training may be viewed in terms of competencies to be achieved in the programs. An alternative approach to competencies for teachers is provided by Poirot, Taylor, and Powell [2].

The competencies proposed are framed in terms of time available. For all teachers these competencies are as follows:

1. Highest priority (initial efforts or if time is short)
   A. Learn to "operate" a computer and run a computer program.
   B. Be able to evaluate computer-based learning materials.
   C. Know styles of using a computer to address major classes of objectives, and know characteristics of these styles.
   D. Know sources of related information and resources.

2. Medium Priority (for next effort, or if a longer period of time is available)
   A. Experience a substantial variety of computer assisted learning.
   B. Experience and practice in using computers as a presentation aid.
   C. Know related technologies (from calculators to video displays to voice synthesizers).
   D. Know vocabulary and basic system components.
   E. Know a word processing system (at least among all teacher who cause students to prepare and improve written material)
   F. Know the roles of computers and implementation strategies relative to the content one teaches and classroom management.
   G. Know the potential impact of computers on society.
   H. Know of the potential impact of computers on education processes.

3. Lower Priority (future training or extended training programs)
   A. Experience in communication with a computer in a language environment a computer "understands".
   B. Know the nature and uses of a variety of information processing systems.
   C. Know information on future developments in computing such as intelligent instructional systems, and voice creation and interpretation. Be aware of relative state-of-the-arts, and reasonable expectations for future developments potentially useful to learning.
   D. Know processes of selection of hardware including topics related to individual microcomputers and to networking.

4. Advanced Experiences
   A. Know instructional design applied to computer media.
   B. Know curriculum structuring and flow in one's subject area and how to modify this to fit computers as an aid to problem solving and as a source of problems in one's subject.
   C. Know authoring or programming languages to implement knowledge of 4A and 4B.

This material could be structured into a series of in-service seminars extending over a school year or longer.

In the case of individuals trained in the pre-service programs discussed in the previous section it would be anticipated that the teacher of computer science would teach computer literacy. Where in-service instruction is necessary in order for computer literacy to be taught, the teacher of computer literacy would need the following additional competencies:

A. Be able to discuss and teach others about the knowledge and skills expected of all teachers.
B. Know the roles of computers in work and careers.
C. Be able to discuss and demonstrate the major classes of applications software potentially useful to a major cross-section of people.
D. Know sources of resources for teaching computer literacy.
E. Know how to program at least at an intermediate level.
F. Have an introductory level knowledge of hardware design, such as the role and function of parts or components of a computer system.

For the individual who is to become a teacher of computer science through in-service training, the following competencies, in addition to those for the teacher of computer literacy, are required:

A. Knowledge and skill in two high-level computer languages at least one of which is structured and one of which is interactive.
B. Detailed knowledge of microcomputer systems including networks.
C. Knowledge of the history of technology and computing.

D. Knowledge and techniques of organizing and structuring information for computer processing.
E. Knowledge of the process of problem solving and algorithm development.
F. Knowledge of a breadth of applications.
G. Experience with a machine or assembler language.
H. Knowledge of methods and curricular organization for teaching computer science including the consideration of the areas of psychology and development pertinent to the level of teaching.

It should be recognized that there are some differences in depth of coverage associated with the level at which the teacher is working.

The College Entrance Examination Board is developing and testing an Advanced Placement exam for a high school computer science course. This is a year long course, involving study of a variety of computer science topics including Pascal programming. The teacher of such a course needs a substantial background in computer and information science, roughly equivalent to a modern bachelors degree. Alternatively, the teacher may have a masters degree in computer science education, as is discussed in the next section.

As indicated earlier, the primary role of the Colleges of Education will be to supply resources and resource people for the programs. The personnel supplied will cover a variety of roles: casual resource people, workshop leaders, short course leaders and teachers for standard length in-service courses. Additionally, long-term resource people or interns will be needed to serve as on-site facilitators, demonstration teachers and evaluators. Naturally the in-service training efforts must be responsive to previously defined needs and requests of the schools served. As a result there will not be a rigid continuum for these various audiences.

Finally the question of in-service training within the College of Education itself must be addressed. In many cases there are currently few individuals in the institutions adequately equipped to deal with computers in education. A variety of traditional approaches exist including the following:

A. Introductory seminars led by an interested faculty member.
B. Introductory seminars led by people from another college or university.
C. Special leave programs for interested faculty to become proficient.
D. Loan of equipment to faculty for office or home use.
E. Presentations by publishers or vendors.
F. Research and faculty development grants.
G. Individual contracts.
H. Creation and use of institutional purchasing and privileged tax status to purchase personal/professional equipment and resources.

In addition to these, the professional societies and specifically the Association for Computing Machinery should play a role such as establishing regional faculty development program leaders and seeing that they are provided with appropriate equipment, media, and resources. The societies should also establish a program by which a university wishing to expand its program could obtain the assistance of a particularly knowledgeable individual for a year.

Graduate Programs in Computers in Education

With the expansion of the application of computers in the schools there is a need for more intensive advanced study in the areas than can be gained in the in-service programs. The Colleges of Education must respond with appropriate graduate level programs in this field as they have in other academic disciplines. The Master of Arts in Teaching degree is as suited to computer science as it is to all other academic areas where it now exists.

The first MAT degrees in computer science were started in 1969 and 1970. Such programs were few and far between until the past two years, but now are growing rapidly in number and enrollment. One might view these programs from the perspective of the educators they serve, the needs they fill (that is the types of jobs the graduates will fill), or the course contents and facilities and staff required.

The typical person now entering a masters degree program in computers in education is a teacher with little or no formal training in computer science. Informal background may consist of attendance at some workshops and a limited self-taught knowledge of a language such as BASIC or PILOT. Some individuals will have taken a FORTRAN course a number of years ago, or will have more recently taken a course or two at a local college. Rarely, however, does an entering student have the equivalent of a modern one year sequence of computer science coursework. This then becomes a fundamental design consideration for such programs. As the in-service and pre-service programs described in the previous two

sections become more available the situation should improve and the Colleges of Education must be alert to and adapt to these changes as they develop.

A second major design consideration is when the students are available. The late afternoon, evening, or weekend program is appropriate for in-service teachers. A summer program is also appropriate for this group. Occasionally teachers have access to some type of leave program and thus can participate in traditional daytime courses.

The needs these individuals seek to fill are diverse. We have noted that computers will become increasingly common in elementary and secondary schools, and they also will become increasingly available for educational purposes in homes, libraries, science museums, and so on. We will consider three main categories of jobs that might be filled by people with a masters degree in computers in education:

1. Specialist in teaching about computers

This would include teachers of computer science and information systems (business oriented) at the elementary and secondary level. Such specialists may also play a major role in helping modify the current curriculum to reflect appropriate roles of computers. The type of competencies expected of such an individual would include the following:

A. Be able to program reasonably well in at least two languages and have a moderate knowledge of at least one additional language. Suitable candidates include BASIC, COBOL, LOGO, Pascal and PILOT as well as other less widely used languages.
B. Be knowledgeable in the general programming processes that apply regardless of the language being used.
C. Be skilled at using a word processing system, a computerized information retrieval system and computers as an aid to learning in a variety of academic settings.
D. Be a center for the collection and dissemination of computer-related information within a school building or school district, helping to keep other teachers and school administrators appropriately up to date.
E. Help to acquire and organize a school or school district's collection of software, hardware, or related print materials, working with media specialists and other personnel as appropriate.
F. Be in charge of or help organize the effective placement of computer facilities in a building or district.
G. Be able to organize and run in-service training for other educators.
H. Be responsible for maintaining hardware by making minor adjustments or repairs and by dealing with repair service people.
I. Provide leadership in revision of curriculum to appropriately reflect computer capabilities and availability.
J. Continue to keep current in the computers-in-education field.

There are additional requirements that may be job-dependent. The computer specialist in a high school should be able to create and teach a full range of computer and information science courses needed in the school. This might include an advanced placement course for a select group of college-bound students and appropriate business data processing courses for business oriented students.

2. Specialist in Teaching Using Computers.

The specialist in this area will be able to find, evaluate, prepare, and use a variety of computer assisted learning materials. The specialist will have competencies such as the following:

A. Be able to establish, manage, and maintain a large library of computer assisted learning materials.
B. Be skilled at evaluation of CAL materials.
C. Be skilled at helping other teachers to learn to use CAL materials and to integrate them into their teaching.
D. Be able to design and develop a variety of CAL materials, including drill and practice, programmed instruction, and simulations.
E. Be skilled in use of a computer as an instructional management tool.
F. Be skilled in the development or modification of "conventional" curriculum materials that adequately reflect computer capabilities and availability.

3. The administrator of computers in education.

If an institution trains school administrators it should provide training in the administration of computer based information systems. Increasingly schools will use computing to assist in the management of financial and other routine record keeping and operation tasks and will turn to sophisticated systems for help on projection of costs, enrollments, benefits, and so on.

The administrator must receive an introduction to system analysis. It should at the minimum expose the student to a wide range of the operation of school administrative systems, acquaint the trainee with their strengths, shortcomings and costs including maintenance, and it should also include an extended effort by the trainee to undertake the analysis and design, apart from programming, of a relevant school system such as a grade report or attendance system. The trainee should emerge with a sense of the advantages and disadvantages of buying versus creating software.

The administrative trainee should also be given experience with evaluating and pricing alternate hardware and software for relevant administrative purposes. This should stress the importance of the existence of a community of users, of vendors, usability of documentation and vendor support.

With this as background, we come to the specifications of the program. A typical masters degree program in computers in education requires approximately 30 semester hours (45 quarter hours) of credits. Roughly speaking we can identify categories of entering students:

1. Those with training or experience equivalent to a first course in BASIC programming, or less.
2. Those with a solid foundation in programming using modern methods.
3. Those with two years of coursework from a modern computer science undergraduate degree program, or the equivalent.

Those programs that accept category 1 students may have different overall goals and outcomes than the programs accepting only applicants from category 2 or 3.

Computers in education has a vertical and horizontal structure. A twelve month (or four summers) program for category 1 individuals might have only three or four levels of depth. Students with category 1 background may spend a substantial part of a first semester (or spend a summer or two) getting up to category 2 level. Thus the admission requirements dictate the depth of the program.

Breadth will depend on the total credits in the program and the nature of coursework available. There is a tendency for masters programs accepting category 1 students to require more total hours of credit in the program than do programs that accept only category 2 or 3 students.

A minimal program would be one which accepts category 1 students and requires 30 semester hours credits. A medium program requires 30 semester hours for category 2 students or 36 semester hours credit for category 1 students. A strong program requires that students have, or build a category 3 background and add 30 or more semester hours credit onto it.

The degree program may be viewed as a sequence of levels and areas. Courses at a given level may be taken simultaneously and have one or more lower level courses as prerequisites.

Level 1 - Introduction

A. First course in structured programming in a traditional language such as BASIC or Pascal
B. Introduction to (overview of) computers in education (eg. [3],[4],[5])
C. Look at the use of a wide variety of software, courseware and hardware. Learn how to evaluate software and hardware.
D. Uses: Word processing, telecommunications, information retrieval; perhaps administrative systems and related instructional systems.

Level 2

A. Second course in structured programming in the same language used in level 1A.
B. Second language(s) such as LOGO, COBOL, etc. The purpose here is to see that the student knows one language well and a second language at least moderately well.
C. Design, development, and implementation of computer based instructional materials. Use of a language such as PILOT.
D. Computers and curriculum content. Explore how computers change content of

non-computer courses.

E. Computers and society. This could be level 2 or level 3.

Level 3

A. Masters degree project. If the degree program has four levels of depth one might begin the project at level 3 and finish it simultaneously with taking level 4 coursework.

B. Specialized computer science courses for the person who will be an elementary or secondary school specialist.
Possibilities include the following:
   1. Graphics
   2. Artificial Intelligence
   3. Information Retrieval
   4. Modelling and Simulation
   5. Software Engineering

C. Special courses for people taking a computer assisted learning emphasis.
Possibilities include the following:
   1. Authoring languages and systems
   2. Adaptive testing
   3. Learning theory

D. Special courses for people taking an administrative emphasis.
Possibilities include the following:
   1. Administering a computer center
   2. Management information systems

The overall program is then structured as follows:

1. Programming core 6-9 semester hours credit
2. Overview core 12 semester hours credit
   a. Overview of computers in education
   b. Computers in society and ethical and social issues
   c. Microcomputer hardware and software systems
   d. Computers and curriculum content
3. Masters project 3-6 semester hours credit
4. Specialization area and electives, approximately 9 semester hours credit

The project (3) could be a field placement or internship, a software development project, a research project and so forth.

To support such a program it is essential that a variety of hardware and software be available. At a minimum there must be at least two kinds of microcomputers and a large computer or sophisticated network of smaller machines.

The key to staffing requirements is to obtain competent, interested individuals. Initially, at least, the program will require using staff from computer science and whatever other departments might be able to help (such as business administration for the administration specialization area). Adjuncts from outside the University may be used with some care. These may be previous graduates of the program, people from business and industry and so forth.

It is necessary, however, that there be knowledgeable people within the College of Education to run the program, and the long term success of such a program demands developing an adequately prepared staff to both administer and teach in the program.

While this program is primarily conceived as a terminal professional masters program, some students will use it to go on to a doctorate. While this may be a topic for future discussion of this subcommittee, we feel it premature to present anything on the doctorate at this time.

Research in Computers in Education

As in any academic discipline, if programs of excellence are to be developed in computers in education, there must be a strong supporting program in research. Research in computers in education is a vitally important area to a College of Education and should be clearly differentiated from the use of a computer as a research tool, which is also an important area but is outside the scope of this report.

It must be recognized that research in computers in education may take forms different from traditional educational research and require some non-traditional methods of communication and dissemination. Those involved in these area must be recognized in terms of those things they do, not in terms of the classical mode of research found in the College of

Education (or in the college in which computer science resides).

Examples of the types of work that might be done include the development of instructional materials as a scholarly activity, or the comparison of language design features as it affects the development of instructional materials. Clearly many pitfalls exist to such work. For example a great deal of learning is not fully understood and thus it is difficult to imagine that it will be fully understood where a computer is used. It is also difficult to always see how a computer may be used in novel ways in a system as structured as the school system. As a result it is very important that failures be reported and as well documented as successes.

The audience for such research is almost unlimited. It would include the faculties of the Colleges of Education and other individuals who determine the instruction of the classroom teacher, and direct instructional programs. Also included would be the computer science faculty, and vendors and publishers.

Types of research, at a variety of levels, and involving both short term and long term effects would include the following:

1. Teaching of computer science (programming issues, at what age, structured versus unstructured and so forth).
2. The effect of computer interaction on skills essential to learning (independence in learning, attention span, following directions).
3. The effect of computer interaction on social development (natural language development, socialization, ethical and moral development).
4. Development of CAI materials (new things that can be taught, arranging conditions).
5. Methods of implementation of computers in education (types of labs, color versus non-color display, AI, expert systems).
6. Role of graphics.
7. The effect of interactive information retrieval systems upon the overall curriculum and the teaching/learning/knowing of a discipline.

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COMPUTER EDUCATION AND COLLEGES OF EDUCATION

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Introduction

Thirty years ago the application of computer technology was restricted to high level research projects and activities involving prodigious amounts of calculation or data processing. Computers were so expensive that only governments and a few large corporations could afford their use. Today computer use pervades our society and public schools are using them both as tools of education and as topics of education. The degree and rapidity of this change has introduced a deficiency into teacher education.

While a few educational programs (both college and pre-college) have had computers for up to twenty years, most attention to computers by educators has developed in the past few years. At present, the general state of computer education can be described anecdotally as follows. Recently, a secondary teacher was given the task of developing a K-12 computing curriculum IN TWO WEEKS TIME! Math and science teachers are commonly assigned to teach computer classes with no formal education related to computers. Graduate students are asked to develop computer use guidelines and curriculum for colleges of education, solely because they have had one or two computer classes.

These examples serve to highlight a statement made five years ago by William G. Cunningham, when he guest-edited for Phi Delta Kappan on the topic of education and technology, particularly computer technology.

> "In an era in which special attention is being focused on alternatives to traditional modes of education, much too little is known or agreed upon concerning the development and impact of educational technology." [Cunningham, p.462]

That issue of Kappan was essentially a call for more thinking and planning about the use of eduational technology. Whatever thinking and planning has occurred seems to have had little concrete results. Even now, five years later, a survey indicates that twelve of the largest 20 undergraduate teacher education programs in the United States have no computer literacy requirement for their students [Electronic Learning, 1981]. Six of those schools did require computer courses for "some" of their majors, but only one did so for all their students. Such a situation is especially disconcerting to computer educators who view literacy as only the beginning of computer education for teachers.

Andrew Molnar, of the National Science Foundation [Molnar, 1978], as well as other educational leaders have called for a national effort to bring computer technology into education. Government action in science education after Sputnik and more recently in the handicapped education area provide examples of what could be done. The chances of such an effort related to computers, however, appear to be quite slim for the foreseeable future. Thus it is important that educators and computer educators work together on the computer education problem, making use of their different knowledge and resources.

The rest of this paper provides insight into the views and environments of these two groups. First, a computer education view of the current state and potential of computers in education is presented. This is followed by a look at the "typical" college of education environment.

Computer Education

Computer education, as used in this paper, refers to inquiry into the applications and implications of computers in/for education. People in this field have widely varying backgrounds. Some are from education and various levels are represented. Others come from Computer Science, Mathematics, and other sciences. Industry is also represented. Computer educators are often much more knowledgeable of computers than of education. They also tend to segregate themselves, as they often are not fully accepted either by those in their original fields or by educators.

As with most areas of inquiry, computer education offers a variety of special interests. Some computer educators focus on using computers in the delivery of instruction while others examine computers as topics of instruction. Some address philosophical and future issues and still others attempt to change the cognitive processes of students through the

use of computers. The field truly is greater in both breadth and depth than is generally recognized.

Computer Uses in Education

Some examples of the acknowledged uses and impacts of computer technology in/on education illustrate this breadth and depth. Perhaps the easiest use to accept and understand is the use of computers as a record keeping device or administrative tool. Businesses have long made use of computers this way. Almost all records kept by school districts, schools, and teachers can be computerized. Attendance, individual student progress, pre- and post-test scores, and compentencies demonstrated can be stored in and processed by computers. Diagnostic testing and prescription can also be done or be aided by computers. Once such systems are installed and teachers familiarized with them, considerable amounts of time and effort can be saved.

A second area where computers can be used in education is in the delivery of instruction. Computers can be used as a delivery tool that combines the characteristics of blackboard, overhead projector, slide projector, movie, lab demonstration, field trip, etc. Additionally, they can be used in a more stand-alone mode to deliver personalized programmed instruction to students.

Curriculum Impact

The combination of these capabilities in instuctional management and delivery offer much, but the impact of computers on education is not limited to them.

Another rather obvious impact of computers on education is the introduction of a new content area -- study about computers. A variety of vocations will increasingly require computer knowledge. Computers are likely to be pervasive in society to the point that survival skills will be changed. Informed public policy decisions will require computer knowledge. Indeed, computer related technology may expand the three R's of basic education to include computers.

Whether or not the definition of basic education comes to include computer education, the current curriculum will be affected by computer technology. A variety of such effects are probable and most impact both the process and content of curriculum. In mathematics, problem solving will be emphasized over calculation. Science experiments will focus more on the experimentation process when computers are used to help collect and analyze data. The teaching of writing will emphasize communication and revision rather than penmanship and spelling. Computer art and music will continue to develop as legitimate areas of creative endeavor. Indeed students will have much greater opportunity to actually create and compose. These and other applications of computers depend not on technological advances, but on human desire to implement them.

Some Other Issues

The discussion thus far has been restricted to the most common aspects of computer education. A more extensive treatment can be found in [Taylor 1980]. An examination of these common positive aspects of computers is important. It should not, however, constitute the entire computer education effort. Some other important questions require study.

> What are the unintended effects of computer applications in education? Will they continue the sex differences seen in the area of mathematics? What kind of image or role will students place upon the computer? How will significant amounts of computer interaction affect students?
>
> How much computer knowledge is necessary for teachers? What happens when students are more knowledgeable than teachers? Should the teacher or the student control the student's use of the computer? Does the locus of control make any difference in the learning process?
>
> Weizenbaum [1976] contended that rather than saving the day when banks were overburdened with paperwork, computers may well have stifled creativity and perpetuated an outmoded system. Is the same thing likely to happen with education?
>
> Can the computer be used to create an environment that will drastically alter the problem solving metaphors used by students? [Papert, 1980]
>
> What impact will the computer have on the aims of education? Will mass computerization of knowledge and common problem solutions change what people

need to know, and thus the goals of education?

These questions may have little to do with the immediate problem of too few knowledgeable teachers, but they certainly need much more exploration when planning for the future. Indeed, it is imperative that these and other such questions be addressed!

From the perspective of computer education, any study or planning in education that does not include computers is incomplete. Such study and planning should take care to consider not only computer uses, but also the context of the uses.

Colleges of Education

The approximately 600 public and private colleges of education in the United States vary in size, environment and philosophy. Some focus on "teacher" education. Some also include studies for various specialists, administrators, and educational researchers. Colleges of education vary in their location on a teacher-training versus research continuum. Additionally, some exist in liberal arts environments while others are more specifically training oriented. All such institutions, however, have the common goal of producing competent professionals.

This goal makes colleges of education similar to other professional training institutions. A difference exists, however, in their degree of control over curriculum. Most professional training is essentially determined solely by the profession or those who actually deliver the instruction. Colleges of education, however, are not in full control of their curriculum. A variety of forces impinge on teacher education programs.

Influences on Colleges of Education

Some of these forces are external to the instituions' immediate environments and the most significant of them is government. Federal laws, regulations, and funding have a great impact on public education. Such interventions may have immediate effect in public school classrooms and colleges of education attempt to supply needed skills and knowledge. These attempts do not always prove to be highly successful, but are made none the less.

State governments also affect college of education curriculums. Two major examples of this are the establishment of requirements for graduation from public schools and the development of guidelines for teacher certification.

These particular examples illustrate a circuity of influence on college of education programs. Teacher certification requirements obviously have impact on such programs. At the same time, however, colleges of education are rarely excluded from the development of these requirements. Other external influences are also mediated by colleges of education. College of education personnel conduct and interpret research that contributes to the development of laws, regulations, funding patterns, and public perception of education. They also are involved in the program accreditations conducted by NCATE (the National Council for Accreditation of Teacher Education) and by various state agencies.

While colleges of education have some influence on the external factors that affect them, it is obvious that they do not actually control them. This is especially true when one looks at any particular program. It may or may not have had people involved in the above mentioned activities.

Besides external influences, colleges of education have a variety of internal influences to contend with. For example, they have to work within faculty and university adminstrative frameworks. Additionally, individual faculty members have differring interests and philosophies. This leads to different perspectives in the student coursework, if not to different content. These internal influences may be familiar, but can be easily overlooked when examining the environment of colleges of education.

Typical Programs

Regardless of the various internal and external influences, teacher education programs throughout the nation are perceived to be similar in structure. Most of them involve several university curriculums. Much student work (40-75%) is primarily aimed toward meeting general undergraduate degree requirements. The typical college of education offers one program for elementary teachers and one for secondary teachers. These two programs usually differ significantly in who administers the bulk of student coursework.

About 50% of a prospective elementary teacher's coursework is provided by a college of education. Some portion, about 10%, is offered by other university divisions (eg. Music, Art, and PE) in a collaborative effort. The major aim of such a program is generality of knowledge, since an elementary teacher is responsible for almost all the curriculum at a

given grade level.

Secondary teacher preparation is much more a cooperative effort, as colleges of education supply only 25-30% of the student work. Various subject matter disciplines are responsible for the remainder of an education student's major courses. The content specialization of the prospective secondary teacher is essentially the same as that required for an undergraduate major in that discipline. The college of education simultaneously provides background in general theories and practices in education. Some subject specific work (methods courses) is also provided by colleges of education.

Obstacles to Change

From outside colleges of education, it often appears that colleges of education have almost complete freedom to specify a significant fraction of student work. The above discussion and an inspection of most any teacher education program indicate otherwise. In fact, there is little flexibility to change such programs. There is little or no room for new requirements. Indeed, many college of education faculty feel the time allocated to existing content is inadequate.

Additionally, colleges of education would have trouble staffing any new courses that could be added. There has been a substantial decrease in college of education enrollment. Federal funding for educational research has diminished. Thus there is little opportunity or money to staff any addition to the current curriculum. Finally, there are few qualified personnel to fill such positions.

Sooner or later, however, colleges of education are sure to include computer education. Public schools are now using computers much more than ever before. Colleges of education wishing to remain abreast of and/or influence these efforts must take action now. Five years ago it was noted that "The next 10 years have the potential for enormous change in education; however, the success of these changes will depend on the quality of planning done by education leaders." [Cunningham, p.462] Such planning has occurred in some colleges of education, but little or nothing related to computers has occurred in many.

Summary

The views and environments of two groups interested in education, particularly teacher education, have been presented.

Computer educators have identified a variety of applications, potentials, and unanswered questions relating to the use of computers in education. Teachers need to be provided with this information and with some guidance in the application of the technology.

Colleges of education provide the mechanism for and experience in teacher education. Curriculum revision and staff acquisition or retraining to meet the needs of computer education are major obstacles to be overcome. The environments of colleges of education are not, however, conducive to making these changes in a timely manner.

The rest of the papers in this collection indicate that some successes in computer education do exist. It is hoped that these examples can provide assistance for further incorporation of computer education into teacher education programs.

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COMPUTER LITERATE TEACHERS-
A POSSIBLE DREAM

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Introduction

The city of Saskatoon is in the process of building a four-lane bridge across the South Saskatchewan River. The College of Education is developing a series of courses to provide teachers with a background in the instructional use of computers. By coincidence, the physical construction of the bridge occurred at about the same time as the process of course development was undertaken. These two separate events are related in a more impressive way. An examination of the time lines set out for course development and actual experience to date reveal that my initial reaction was correct: "They can build that bridge faster than we can add a course to our calendar."

The University of Saskatchewan is a beautifully situated on the east bank of the South Saskatchewan River, across from downtown Saskatoon. Some 12,000 daytime students attend, 1,700 of these in the College of Education, and a total campus count of 1,100 graduate students. The faculty numbers approximately 1,100. Within the College, 380 elementary and 195 secondary teachers and 77 graduate students were approved for graduation in the past year by our 78 full time faculty members.

An Overview of Computational Science at the University of Saskatchewan

In the mid 1970's, the Department of Computational Science (currently housed in the College of Engineering) adopted the philosophy that a student's first experience with a computer language should be in a structured language. Furthermore, the algorithmic approach to problem solving was preferred over flow-charting, and other current strategies such as top-down design and introduction to data structures were implemented in the first-year courses. The language chosen was the subset PL/C, with the later expansion to PL/1. The changes were implemented in all first year Computational Science classes. More traditional languages were still available in several classes for Engineering or Commerce students and for upper year electives in Computational Science majors and minors.

Current revisions to the computer science offerings include the introduction of PASCAL in compulsory second year courses. Only the limitations of adequate string manipulation in our current implementation of PASCAL has kept in from earlier, widespread use. It is fair to say that the widespread availability of microcomputers and BASIC at the non-college level have hindered the effectiveness of these decisions, as the high schools are often producing students (many are self-taught) from a more traditional unstructured flow-charting orientation.

Also worthy of note is the heavy student demand for courses in the Department of Computational Science. In a time of retrenchment our department, like most computer science departments, as been unable to expand its faculty numbers in a manner which approximates the increase in student enrollments.

Details of required Computational Science courses are discussed in this paper.

A Primer of Course Development

The College of Education is arranged into departments, the largest of which is the Department of Curriculum Studies. This department contains subdivisions of subject area specialists, e.g. math, language arts, social studies, and others. Within the college are three assistant deans who head up the undergraduate elementary, secondary and graduate programs. The two Program Advisory Committees (EPAC and SPAC) make decisions and recommendations to faculty regarding changes in the Elementary or Secondary Programs. Thus, the organization of the college may be viewed as being two dimensional--the departmental component which proposes and offers new courses and the program component which approves required and elective courses for students in the several programs.

Finally, the program advisory committees have set up subcommittees for each secondary major or minor and each elementary area of concentration. To insure wide representation, the subcommitees are constituted in the following manner:

Representative(s) from the College of Education subject area.
Representative(s) from Arts and Science related departments.
Representative(s) from the teaching field chosen by the Saskatchewan Teachers' Federation.

These subcommittees of the EdCur Department are usually the originators of proposals for changed or new courses relating to methodology. Likewise, the Assistant Dean may see areas of concern and suggest that a department or subcommittee consider a matter.

It is also helpful to know that, basically, the College of Education provides the "methodology," foundations, educational psychology and instructional technology. While this is the norm, if one of the two colleges is unable or unwilling to provide needed services, the other can then develop and/or offer content or methodology courses when needed. Examples of cross-overs in both directions could be cited.

New courses must be approved by the appropriate subcommittee, the Department of Curriculum Studies, the related Arts and Science Department, the appropriate program advisory committee, the college Senior Committee on Studies, and college faculty, and the campus Academic Affairs Committee. In the case of the Computers in Education courses, the matter was deferred to the College of Education Computer Utilization Group for consideration before being sent to the college faculty.

In the early fall of 1981, by common agreement between the Assistant Dean and the chairperson of the Mathematics Education Subject Area, a computer science subcommittee of SPAC was formed. It was agreed that the same committee would serve the elementary program.

This committee consisted of three mathematics educators (each with some computer science background, one of whom has a graduate degree in Computers in Education), two computer scientists, one secondary computer science classroom teacher, one school district consultant (in mathematics and computer science) and one representative from the mathematics department. This subcommittee was to review general computer experiences of pre-service teachers, propose majors and minors and methods courses for secondary teachers and areas of concentration for elementary teachers, and to propose elective courses in computers in education.

Formulation of Courses

When the subcommittee met, certain ground rules were quickly agreed to. Among them was the need to provide computer background to pre-service teachers. For many teachers the need to learn the language common to educational applications, BASIC, was deemed an appropriate starting point. Also, a course focusing on educational applications and especially upon classroom use was desired. It was further agreed that the Department of Computational Science had neither the human resources nor the desire to implement such a course. Yet, there was agreement that the programming and problem solving skills of the course should be taught so as not to contradict the philosophy of other Computational Science offerings. Hence, it was agreed by this committee that the courses developed would carry a designator of "CMPED" and staffing would be a joint responsibility of the departments involved. This would reflect and protect the legitimate concerns of each department. Based upon these premises, majors, minors, areas of concentration, two sequential three unit (semester hours) courses and a computer science methods courses were developed. These course proposals, all at the undergraduate level, will be discussed in detail later in the paper.

A Multiplicity of Audiences

It was agreed that every classroom teacher should have an awareness of the general uses of computers in the classroom, hands on experience in operating canned programs, and some CAI learning experiences. Teachers wishing more knowledge should be able to choose three to six units of elective courses in computers in education with no Computational Science prerequisite. Teachers wishing to specialize should take at least the compulsory courses from the Computational Science major plus electives as program requirements permit. These students should include a computers in education course or methods course in their programs.

Furthermore, there are many practicing teachers who are interested in courses such as those under development. The needs of teachers pursuing graduate studies also must be addressed. Thus, a multiplicity of audiences for these courses was identified.

The Proposed Delivery System

It is evident that the place to learn about the general uses of computers in education is

in the general classroom--NOT only in computer science and computers in education classrooms, but in a variety of classrooms. Those skills needed by every teacher must be addressed in existing required courses. This is easier to implement than is another required course or part-course. This implementation was well underway before the development of formal computers in education courses. I feel safe in stating that every undergraduate preservice teacher in our college has approximately ten contact hours with computer assisted learning. For secondary teachers, this comes from a package entitled "Critical Incidents in Education" [1] in a required general secondary methods class. In the elementary program, such experience is included in the required mathematics methods courses. Thus our students have had an opportunity to operate a computer and experience learning with the aid of a computer. Other areas such as early childhood and language arts and social studies are also incorporating computer related experiences into their courses. More subject areas are investigating the uses of computers in classrooms every semester.

To meet the needs on an introductory level of the general classroom teacher, a three credit hour course, CMPED 218, Introduction to Computers in Education, was outlined. This course summarizes the historic steps in the development of current computing technology, both hardware and software trends, proposals for widespread delivery networks, issues such as physical or emotional side effects, and a wide range of instructional technology ranging from the LITTLE PROFESSOR and SPEAK and SPELL to sources of software for micro-computers. On the programming side, introductory level programming techniques in BASIC through single dimension arrays will be included. Problem solving, based on the development of general and specific algorithms, is central to the course. Program documentation and modification skills are also included. The prerequisite to the course is a college preparatory grade 12 mathematics credit. As this is essentially an entrance requirement for most of the college programs, it is not a severe screening constraint. It would be fair to conclude that the computers in education aspects of this course is treated in greater depth in the following course.

CMPED 418, Applying Computational Technology to Education, is a three unit course designed to meet the need of several audiences. Students with only an introductory level, three credit computing course, can meet the prerequisite. Furthermore, students in the elementary program with an area of concentration in computational science will use this course as a professional course in their field of specialization. Teachers in the elementary program generally teach in grades K-8, and students in the secondary program will teach in grades 7-12. Thus, there is some overlap. An area of concentration in the elementary program is defined to be 15 units, three of which are in the professional area. Hence, these students with 12 units of computer science will have a stronger subject matter background than those coming directly from the CMPED 218.

This course will provide students with an introduction to a structured language (either PASCAL or structured BASIC) and include work with various loop structures, subroutines, and parameter passing. Advanced string manipulation, graphics, multidimensional arrays, files, and searching and sorting techniques will be included. Students will be expected to apply these techniques to the design, development, and critique of a major education application. Hence, a detailed study of educational applications and criteria for evaluating such software will need to be included. The prerequisite is CMPED 218 or three units of computer science and the ability to program in at least one language.

EdCur 319, Methods of Teaching Computer Science in the Secondary schools, is a three credit Curriculum Studies offering. It follows the traditional mold of methods courses. For majors and minors, the course will examine current and proposed computer science curricula, including computer literacy. Methods and material for developing concepts will be reviewed. An introduction to the use of popular microcomputing hardware and system idiosyncrasies will be included to provide a better transition from mainframe to the microcomputing equipment most commonly available in the schools.

Saskatchewan teachers' certificates are without a specified term and they permit the holder to teach any subject at any grade level K to 11 and some grade 12 subjects. The assignment of teachers is controlled only by the superintendent or local principal. In practice, it is hoped that teachers of a computer literacy unit (50 contact hours) recently developed by the Saskatchewan Department of Education for grade 7 or 8 will have at least the CMPED 218 three credit course. Similarly, teachers of the first level high school computer science course (another 50 contact hours) will have at least six credit units in CMPT or CMPED courses. It is preferred that they be at least minors (18 units CMPT plus three units methods courses).

Math and Computer Science

In the introductory article, East [2] refers to the tendency to assign mathematics and science personnel to teach computer science, even if they lack formal training in the

discipline. On the other hand, we have tried to make sure that prospective teachers other than math/science specialists can pursue a specialization in computer science. The new Computational Science major at the University of Saskatchewan contains the following compulsory six-credit (full year) required courses:

CMPT 110.6 which includes basic concepts of problem analysis, algorithmic development, and programming in a high level language (currently PL/C, with some desire to move towards PASCAL). Basic structures used to organize data are presented and studied in appropriate applications. These structures include strings, queues, stacks and linked lists.

This is the first year introductory level course for majors and minors. The prerequisite is high school intermediate algebra and trigonometry. (Note: the decimal (.6) denotes a six credit course. It would meet 3 hours a week for 2 semesters. Our semesters are about 13 weeks, plus 2-4 weeks for final examinations. A course with .3 would meet for one semester.)

CMPT 250.6 Computer Systems is a six credit course which provides an introduction to computer systems, assembly language, macro assembly, software components, and software design. Prerequisite is CMPT 110.

CMPT 250.6 Analysis of Data and Language Structures is a six credit course which is a continuation of CMPT 110 which further develops language and data structures. Applications of data structures to implementing language features are emphasized. Algorithm analysis techniques are introduced and used to compare algorithms. Topics include trees, lists, graphs, referencing environments, storage management, sorting and searching. Prerequisites are CMPT 110 and Math 210.3 (may be taken concurrently).

Math 210.3 is a three credit one semester course which presents the essentials of discrete mathematics with particular emphasis on aspects related to computational science. Topics include discrete number systems, propositonal and predicate logic, set theory, relations and functions. The prerequisite is at least three units of Math for Business Decisions (calculus). Most students will have six units of university level calculus.

With the above courses and prerequisites it is possible for non-mathematics minors and majors to complete three courses in computational science by taking a third year course on computer organization and hardware in place of the normally required CMPT 250. Students whose programs otherwise include a year of Calculus will have little difficulty with the standard major. Other students may wish to take the "business calculus" course and the Math 210A (a total of one year of Math) to better accommodate the CMPT 250 course. A noteworthy administrative guideline is that unless otherwise required in the program, prerequisite courses, such as math, must be counted as a part of the major or minor. In practice this is translated to the policy: First year Calculus and Math 210A may be credited toward the CMPT major only if they are not required in the student's other major or minor. Where the program permits, the otherwise required CMPT 250 is preferred to the systems option. Thus, we have been partially successful in meeting the needs of non-mathematics oriented students.

Problems Not Encountered

Some of the strengths of the model outlined above were evident throughout the ongoing developmental period. The inclusion of all interested parties in the proposing committee has significant advantages. Concerns and strategies to avoid open battles on the floor of faculty or University Senate were implemented. Fortunately, while the negative aspects of turf protections were absent, it was possible to identify major concerns and protect legitimate interests. When proposals went to the departments involved, members of that department were present to discuss the concerns of their colleagues.

The presence of representatives of the teaching field was also a valuable asset. They could speak to the current, very real needs of school systems in implementing the use of computers in their classrooms. With these current pressing needs and alternatives in clear view, it was not possible to remain bogged down for long periods of time. A long delay in implementing proposals was not an attractive alternative, given the present school needs.

Problems Encountered

Probably the greatest problem encountered is how a College of Education can move into new areas of curriculum and technology in a time of extremely tight cutbacks, euphemistically referred to as "a period of retrenchment." Certainly the hardware, software, and personnel costs cannot be overlooked. Nor is it wise to underestimate them. In the final analysis, this is the point upon which our proposals became temporarily stranded.

Another unresolved issue is how to provide for the needs of teachers-in-service who have completed their first degree. Many of these are interested only in graduate credit. How can an introductory course in a new field, a course which is clearly not as rigorous has those intended for first year majors, be deemed worthy of graduate credit? On our campus, this question has eliminated all progress toward effectively meeting the needs of teachers-in-service who are working in graduate programs. Fortunately, the College of Commerce has implemented an introductory, graduate level course in BASIC as a part of its "qualifying" program. The inclusion of this course in a graduate program is at the discretion of those committees approving a student's program. This course will be effective in meeting the needs of teachers. While it focuses upon the business applications of computers, many of the programming techniques and introductory problems are clearly transferable to education. Furthermore, a teacher should be aware of the variety of societal uses of computers. A focus on business applications and concerns may be effective in achieving this end.

This use of a single introductory graduate computing course is very different from the usual situation in statistics. How many introductory level applications oriented graduate level courses (be they statistics or computer science) are really necessary on a campus?

Perhaps it is merely a matter of timing. In the 1950's, computer programming was the domain of only a few faculty and brilliant graduate students. Later, it became a part of the graduate programs. More recently it has moved into the undergraduate domain and high schools. Papert [3] is now showing us how these skills can be developed in the elementary school. However, by proposing and implementing a graduate level course in the appropriate decade, the needs of graduate students can be served for a long period of time.

In the meantime, how does the College of Education, without approved courses, meet the need or pre-and-inservice teachers. The answer to this is the way all disciplines are equipped to meet change. Every university has a variety of private reading, group seminar, trends and issues, experimental and/or special topics courses. One of the major criteria for the offering of these courses is need, and need is most often measured by the number of students who are willing to enroll in the course. These courses can be used to start a program, and to keep it alive until it can succeed on its own merit. Furthermore, there is nothing to apologize for here--this is a legitimate use of such courses. They are in existence and should be used for situations such as those which are currently occurring in the computers in education and computer literacy fields.

Costs

Nearly everyone agrees that the College should be doing something in computers, but can we really afford it? Certainly any cost estimates must include hardware, software, maintenance of both of these, and personnel. Human costs range from student lab assistants to part or full time technicians and faculty teaching time. Two major unresolved problems are access and security. Perhaps the best location-one that is already staffed-is the library or media center. Noisy printers and sound producing components are, however, a major concern in an otherwise quiet library setting. Our software is currently on reserve in our media center. Microcomputers in unsupervised places are subject, at best, to the development of an atmosphere becoming a commercial games place, and at worst to thievery of parts such as chips, color TV's, tape recorders, software, and interfaces, if not theft of the entire unit. At present the mathematics education budget is financing a major portion of our computing endeavor- to the detriment of the mathematics education program as we are spending less on our mathematics education laboratory. Permanent budgetary considerations need to be made which will provide a high level of service to other subject areas and to the College as a whole.

Another important question which deserves consideration on many campuses with an efficient network of timeshare mini or mainframe computing services is: "Why should the College of Education have any microcomputers." In our instance, it is because microcomputers are in the schools and prospective teachers need some balance of large system and microcomputing experience is a practical alternative.

Strengthening this position is the realization that expensive microcomputer peripherals such as printers and disk drives need to be shared by some kind of networking hardware and software. If students are using a microcomputing system sharing peripherals, then is the difference between this system and a more traditional time-shared system worth the extra investment of scarce funds? Finally, at what point is a microcomputer network too small, and the move to a minicomputer a desirable alternative?

Another factor affecting equipment acquisition is the question of which brand is appropriate. Or should several of the "major" brands be purchased? What about future upgrades (such as new language or DOS versions or color graphics) and the introduction of future generations of microcomputers (e.g. the new 16 and 32 bit processors)? How can a

college keep pace in this rapidly changing scene? If we buy today's technology, how long will we be forced to use it after it becomes outdated, perhaps in two or three years? In spite of the expense, no one can reasonably argue that it is better to wait. Under such a philosophy, one would not yet have purchased a calculator.

Our answer to these questions has been that we would move into the microcomputer market. The major reasons being:

1. We desire to educate inservice and preservice teachers using the equipment available to them.

2. The convenience of microcomputers:

    a) no log-on ritual
    b) security of software is easier to provide, as each individual is responsible for his/her own diskette.

3. Heavy demands on the existing mainframes:

    a) an exponential growth pattern in the record of use
    b) the current version of BASIC is relatively slow and tends to consume memory.

In particular, we have not selected only one brand, but we tend to use two or three brands of micros (and the DEC 2060 is also available). Thus students have an increased chance of finding hardware somewhat compatible with that in the schools. The price is that instructors need to work harder to be familiar with a multitude of systems, and multiple explanations of differing use (e.g., tab vs. htab, graphics, A(0) in arrays...) are required. Finally we are still with the first generation micros (8-bit processors) when we know the 16's and 32's are one the way. At least we have a variety of software currently available. These systems will still be usable long after the market technology has passed them by. Furthermore, one deliberately plans pauses in CAI applications. As long as the screen is filled faster than the user can read it, further enhancements in speed are not necessary in many of these applications. Finally, writers still complain of the dearth of quality software for education, and rightly so. However, when a new generation of computers is unveiled, there is usually no software available, except that supplied by the manufacturer of the hardware. Obviously, this is a minimal commitment. There is a 3-5 year gap before existing programs are implemented on the new hardware. Thus we are content to wait and use our originals while new generations catch up to current standards.

At present we have four APPLE II plus microcomputers with single disk drives and one with double disk. We have four PET 32k micros which are cassette based, and one single and one dual disk (4032). We have a printer for each system. We hope to double the above holdings. We also have six TRS-80's (Level II's) and two Level I's which are cassette based. These latter microcomputers badly need disk drives to enhance their usability. Also available and in use are ten terminals connecting with any of the main campus computers: The DEC 206B, the HP 2000F and the IBM 4341. For our purposes, the DEC is the most used. We are also ordering 3 Super PETS, a MUPPET network and reviewing the specifications for the P128 microcomputer. Considerable as the above investment in microcomputing systems is, it is apparent that a similar amount needs to be allocated for software, software development, maintenance, and hardware upgrades.

In summary, the costs associated with entering the computers in education field are both extensive and ongoing. Any one-time-only grant, however large, is, of necessity, inadequate. Permanent budget allocations are the answer.

The Camel's Nose

One is reminded of the story of the camel who put his nose into the tent to keep it warm. Before long the camel was in the tent and its human occupants were outside. From the author's brief experience with computers in education courses, programming is seen to be "the camel's nose." To develop good software from classroom use, a wide variety of programming skills are essential. These include string manipulation, multi-dimensional arrays, graphics, sound, voice synthesis, searches, and all sorts of sorts. If just one more programming technique could be taught, another whole array of applications would open up. There seems to be no end to the programming techniques which would be useful. It is, indeed, a very large camel.

One area of challenge is to develop a course which would not include any programming skills. It would use a wide variety of prepackaged software including popular applications software such as Visi-Calc [4] (TM), word processing, and other data base manipulation packages. A variety of electronic technology such as DATA-MAN, LITTLE

PROFESSOR, SPEAK AND SPELL, language translators and calculators should also be included. Criteria for identifying good and bad educational software should be reviewed. The major applications areas in education can be discussed. Obviously, this will be a hands on program which studies applications of computing technology at a wide range of grade levels and study areas. Perhaps program modification techniques can be incorporated. But, if so, be careful, as these are often programming techniques and the camel will again be in the tent.

This author has never proposed nor taught such a course. He has, however, often entertained the camel. Such a proposal, a non-programming, computers in education course, is seen as a welcome and interesting challenge.

Summary

This paper has described a course development model which, from its earliest inception, incorporates computer scientists, teacher educators, and classroom teachers as key personnel in attempting to improve classroom use of computers. The model is deemed effective and is highly recommended. Planning at the University of Saskatchewan has arrived at a three-tiered approach to computer education:

1. Inclusion of appropriate materials in compulsory core courses and in other courses.
2. Courses for teachers to be undertaken on an elective basis.
3. Adequate preparation for subject matter specialists including content and methods courses.

Problems which may affect proposals included the question of turf, expansion in a period of retrenchment, financial considerations, graduate credit, and getting started. A special challenge issued was dual in nature:

1. to control the extent to which programming serves as a focus, possibly to the detriment of other topics, and
2. to develop a non-programming based course which would still be hands-on and would meet the needs of teachers.

Implementation of the new program in the Department of Curriculum Studies has been hindered by budgetary restraints. Costs of a computers in education program must be met by adequate permanent funding. One time only grants are simply not adequate.

Through an awareness of the needs of teachers and a cooperative effort progress can be made to the satisfaction of computer scientists, teachers, and teacher educators.

The race with the bridge alluded to in the opening paragraph is still on. Now that the courses have been approved, and our hardware expanded, faculty are being assigned to teach the courses. In some cases this means that existing electives are offered less frequently. A full implementation of these courses is scheduled for this year. The use of the Trends and Issues course as a precursor to CMPED 218 has stopped. However, the courses were not approved in time for the current calendar (catalog). Thus they will not appear until April 1983. However, students and autos are scheduled to start flowing across their respective bridges next term. At least our course proposals were not affected by a carpenter's strike!

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COMPUTER EDUCATION AT ARIZONA STATE UNIVERSITY

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The Past

The College of Education at Arizona State University in Tempe, Arizona, has been involved with computer education activities since the late sixties. Three graduate courses have been offered periodically since 1969. The courses are Computers in Education, Computers in Elementary Education and Computer Programming for Instruction. Computers in Elementary Education has been offered each semester since fall of 1971. The other two courses have been offered dependent upon qualified faculty and student interest. Course descriptions are as follows:

1. Computers in Education
   Selection and utilization of computer programs for use in instructional and administrative settings.
2. Computer Programming for Instruction
   Computer programming in BASIC for instructional purposes. Students develop computer-controlled instructional programs.
3. Computers in Elementary Education
   Computer awareness, societal impact, educational ramifications, classroom applications, curriculum development and future computer implications are emphasized. The BASIC computer language is used as the computer language. Microcomputer hardware and software are emphasized.

The course enrollments in the seventies averaged from 10-20 for these classes when offered. But an enrollment increase has taken place in the early eighties, for example, the enrollment for Computers in Elementary Education over the past year is as follows:

Summer 1981 - 51
Fall 1981 - 21
Spring 1982 - 21
Summer 1982 - 60

The other two courses follow a similar enrollment pattern. The impact of these classes on the community has been extensive. Most of the past computer related activities in the state usually involved students from one of these classes.

The University time sharing computer terminals have been used for programming exercises in these classes. The computer systems have been GE 200 and 400 time sharing in the late sixties and early seventies. A UNIVAC 1170 with time sharing was used until the late seventies. Digital PDP 11-70's have been used since the late seventies. BASIC has been the computer language utilized.

Numerous computer workshops have been provided for local school districts utilizing time sharing computer terminals. The workshops emphasized BASIC programming and teachers often had access to their own terminals in their classrooms. The training included mostly gifted and secondary teachers.

Research activities during the seventies included "Computer Assisted Instruction Efforts via a computer controlled slide projector presentation in Elementary Mathematics", "The Effect of Computer Achievement on the Teaching of Mathematics", and several computer surveys.

Some of the faculty were and are still involved in state, national and international efforts to promote educational computing. This involvement includes computer programming contests, support of local and national meetings and membership in local, state, and national organizations.

The Present

The College of Education (COE) presently has an enrollment of over 1500 undergraduate and 2660 graduate students. It is considered one of the largest COEs in the United States. The college offers the Master, Ed.D., and Ph.D. degrees. A computer sequence is offered as a specialization for these degrees.

The following is the Colleges's conceptual plan for computer education. Educational computer applications are viewed as important facets of contemporary professional

education programs. Integrating computer technology, including microcomputers, into numerous parts of the undergraduate teacher education curriculum is a desirable way to influence practice. As such, it is essential that COE faculty become knowledgeable regarding computer applications in the various curricular areas. This plan does not provide a specific sequence of "computer" courses for undergraduates but rather assumes integrating the use of computers into many facets of the undergraduate program.

College of Education Computer Courses

The areas indicated by the titles represent a sequence of experiences deemed essential to a professional understanding of computers and graduate specialization. When appropriate, prerequisite areas are designated. Nine area are indicated and the parameters of each area are indicated in the descriptors included under each one.

Computer Literacy (administratively designated to be available to graduate and undergraduate students)

Purpose: To provide background in the general role of computers and their specific use in education

Role of computers in society
Role of computers in educaton
Elements of programming
Hardware and software evaluation
Research implications
Educational applications
Word Processing utilization
Computer managed instruction

Graduate Classes

Computer Programming

Purpose: An introducton to BASIC which takes the student through the fundamentals of the language, up to and including flow-charting and loop control.

Introduction to BASIC language
Language strategy
Flow-charting - program design
Data structures - numeric and string
Loop control
Searching and sorting
Formatted printing
Manipulating and processing words

Files and Word Processing Applied to Instruction (Pre-req: Computer Programming)

Purpose: Applying file capabilities and string manipulation to computer managed and computer based instruction

Arrays
Matrix handling
Single and double-scripted variables
Manipulating and processing words
File handling - sequential and random
User defined functions

Computer Applications for Administrative Functions (Pre-req: Computer Literacy)

Purpose: Applying computer technology to administrative tasks

Computer mechanics and vocabulary
Effects of hardware on software applications
Procuring and maintaining hardward/software
Analysis of uses in administrative functions
Selection of courseware and software
Resource management, e.g. managing the library or monitoring student progress
Word processing utilization

Selection and Utilization of Computer Materials (Pre-req: Computer Literate)

Purpose: Evaluating software that is environment and content specific

Evaluation of hardware and software
Assess limitations of software and hardware in schools
(Integrate the computer into the existing curriculum)
Hardware
(Capabilities, comparison of costs, preparing bid specifications)
Methods and procedures for using in instruction

Research in Computer Education (Pre-req: Either of the above courses)

Purpose: Detailed analysis of the research and evaluation that has been done regarding computer applications

Social implications of the technology
Computer applications in schools
Classroom uses of the computer
Cognitive and affective studies related to computer usage

Computer Graphics and Control of Audiovisual Systems (Pre-req: Computer programming)

Purpose: Use of computer as a non-textual display system, including computer graphics and control of audiovisual hardware, such as a slide-tape, videodisc, videotape, audiotape, etc.

Manipulating and processing graphic symbols
Understanding the capabilties of computers in generating graphics
Developing computer graphics
Relating developed computer graphics to instructional programs
Evaluating graphic generation packages
Interface between computer and audiovisual systems
Development of interactive learning systems involving non-textual (stimulus) displays

Computers in Elementary School Curriculum

Purpose: Introductory experiences with educational uses of computers (Computer awareness, family/societal impact, classroom application/software, curriculum development, BASIC/LOGO languages, microcomputers)

Knowledgeable of educational uses of computers
Aware of family and socital impact of computers
Knowledge of classroom applications and problem solving experiences utilizing the computer
Knowledge of one programming language
Aware of microcomputer hardware and software

Special Topics

Since the computer area is expanding rapidly, new areas of inquiry will be emerging. Although no specific topic areas are proposed, workshops in the evaluation and utilization of special-purpose author languages would be an example of the intent of activities.

Infusion Activities - Undergraduate Applications

The undergraduate Elementary Mathematics course has included a Computer Awareness Module since the Fall of 1979. This module requires the students to use microcomputers as they would be used with children. The objectives of the module are as follows:

(1) Learn how to operate a microcomputer;
(2) Load commercial programs into a microcomputer;
(3) Run at least two commercial programs and complete worksheets;
(4) Enter a BASIC program.

Another undergraduate Elementary Education program called PRIME is utilizing microcomputer instruction in its training. The Department of Educational Administration offers a class in administration utilizing the computer. The class emphasizes computerized simulaton of educational administrative decision making. Various other undergraduate and graduate classes throughout the college provide computer awareness activities for their students.

The College of Education through a grant from the Pre-College National Science Foundation provided a computer literacy program for school districts in Maricopa County. The goal for this project was as follows:

This project was to provide well-trained computer resource people within the educational community in Maricopa County. These computer resource people would have skills in:

(1) Conducting professional growth workshops in computer literacy.
(2) Developing effective software selection criteria.
(3) Making hardware selection decisions which are appropriate to implement the computer supported instructional program as developed by each district.
(4) Develop and coordinate in-district authoring teams from among interested faculty.
(5) Assist in the development of computer related curriculum.
(6) Teach computer related courses.

This program involved 15 school districts. Administrators from all cooperating districts were involved in a one day computer literacy seminar. Each district provided teachers who attended an intensive four-week summer computer literacy training program offered by the Arizona State University College of Education. These thirty trained teachers taught twelve on-site computer literacy classes for teachers in cooperating districts. Over 250 teachers were trained by this program. These teachers received local district salary increment or professional growth credit for attending. Several districts are now supporting repeats of those classes for teachers who were unable to enroll in their district's NSF Computer Literacy class. Teachers from all academic disciplines (K-12) were encouraged to attend.

Microcomputer Laboratory

In 1979 the College of Education financed the development of a microcomputer laboratory. Six of the most common microcomputers are represented. Extensive software is also available on a checkout basis. This laboratory under the supervision of a COE Study Group on microcomputers in education has the following objectives:

(1) Provide support for courses already offered in the COE.
(2) Furnish opportunities for faculty to become familiar with characteristics of many different types of microcomputers.
(3) Be utilized for microcomputer research.
(4) Benefit the educational community
(5) Act as a clearinghouse for computer programs.

Numerous school districts and state department personnel have utilized the microcomputer laboratory for preview of hardware and software. The laboratory includes LOGO, PILOT and Pascal as well as a library of commercial and non-commercial software. The laboratory is located in the College's Instructional Resource Laboratory and is not connected directly to any department. The Instructional Resource Laboratory handles all scheduling and security arrangements. A graduate student specializing in computers in education studies is responsible for the laboratory and provides assistance and tours to faculty or classes requesting it. In addition the laboratory is open to the public on Tuesday evenings from 5-8 p.m. The graduate student is available for help as needed.

Microcomputer Classroom - College of Education Microcomputer Instructional Laboratory

The College of Education has now established a Microcomputer Laboratory with 30 Apple III Microcomputers (received through an Apple Foundation Grant). The facility includes a high resolution class screen and networking. Printers and word processors are available. The facility is used for the COE computer courses, seminars, research and faculty development.

Research topics under consideration are as follows:

(1) What computer programs best improve learning skills apart from the computer?
(2) What subjects and objectives are best for simulation and modeling activities using the computer?
(3) What type of programs encourage creativity?
(4) Do drill and practice programs increase achievement?
(5) How can computer activities improve student attitudes toward learning, technology and subject matter?
(6) Does computer programming improve problem solving abilities?
(7) What effect does sound and/or color have on achievement of a CAI program?
(8) What effect does computer use have on values?
(9) What are effective ways of presenting CAI?

Community Support Services

Faculty and graduated students offer numerous workshops and talks to teachers and administrators and interested groups. In the past year, talks were provided in 15 states and workshops for numerous school districts. The COE provides assistance in establishing awareness and developing curriculum programs. Also evaluation and consultation on various computer projects have been provided by faculty and students.

Microcomputer in Education Conferences

In 1980, the College of Education held an annual National Microcomputer Conference. The conference was entitled "Microcomputers in Education: Getting Started." Over 450 were in attendance with 50 speakers and 18 exhibitors. Attendance included participants from many states and several foreign countries. In 1982 the conference emphasized Microcomputers for Education for the 80s. Over 600 attended this conference. Future COE Microcomputers in Education annual conferences will expand to three days of sessions. This annual conference provides support for state educators as well as pre-service and inservice education at Arizona State University.

Research

Research efforts include longitudinal studies in computer literacy, problem solving and programming, and predicting programming success in adolescent children. Additional research effects include preschool computer proposals for preservice integrated microcomputer course development in mathematics, science, social studies, gifted and bilingual education. A research grant proposal has also been written to support efforts to determine the effect of sound and/or color on computer assisted instruction.

The Apple Foundation has supported a three year COE Research Grant for researching remedial mathematics and adolescents. The research is as follows:

The purpose of the remedial mathematics research project is to determine the effectiveness of a microcomputer-based instructional model for remediating mathematics deficits in undergraduate students.

The dramatic increase in remedial (high school level) mathematics courses in colleges and universities is the focus of this research project. Limited resources are forcing universities to look for alternative basic mathematical remediation techniques. This project proposes to research the effect of a microcomputer-based instructional model for remediating mathematics deficits in undergraduate students.

The research model will involve undergraduate students who score below the 70th percentile on the SRA mathematics achievement test. Three treatment groups, (1) computer-based instruction (2) a combination of computer-based instruction and individual-study text and (3) individual-study text will be used to answer the following research hypothesis:

Is computer-based mathematics remediaton more effective that self-study text remediation with undergraduate college students or computer-based remediation coupled with self-study text remediation?

Is computer-based mathematics remediation more effective for students above or below the 50th percentile in mathematics achievement?

Are students' attitudes toward computer-based remediation more positive than toward self-study text remediation?

Are students' attitudes toward computer-based remediation more positive than toward computer-based remediation coupled with self-study text remediation?

If stratified for the number of items missed, (that is, length of assigned programs of study), is computer-based remediation more effective than other forms of remediation?

If stratified by type of computer-based learning, is verbal (non-graphic) Computer Assisted Learning (CAL) more effective than pictoral (graphic) CAL?

Is CAL mathematics retention greater than self-study remediation over a two-year length of time?

The research project will have a duration of 36 months, the first twelve months being used for development and pilot research. The basic research model will be carried out during the last 24 months of the project.

The Future

The following represents an overall goal structure for future planning:

1. Establish national visibility in microcomputers in education.

   A. Participate in national conferences and seminars by presenting papers, chairing sessions, or preparing short courses.
   B. Seek external grants and contracts to support the microcomputer activities.
   C. Establish a working liason with industrial and governmental organizations.
   D. Develop a brochure for national distribution which highlights the facilities and programs developed in support of microcomputers in education.

2. Establish a regional and local visibility in microcomputers in educaton.

   A. Participate in regional and local conferences and seminars which involve microcomputers in education by presenting papers, chairing sessions, or developing short courses.
   B. Distribute, locally and regionally, information about the microcomputer facilities and programs developed at Arizona State University.
   C. Develop an industry/ASU exchange program on microcomputer software and other information.
   D. Provide assistance to the state Department of Education in learning to use microcomputers.

3. Encourage the widespread use of microcomputers throughout the college.

   A. Disperse knowledge to faculty, students, and staff on the attributes of the microcomputer and the potential for its use.
   B. Make the hardware and software systems for microcomputers readily available, easy to understand and adequately supported.
   C. Enable each department in the college to easily produce publishable quality microcomputer applications.
   D. Incorporate microcomputers into college administrative functions.

4. Develop a high level of excellence in microcomputer research.

   A. Provide a variety of available microcomputer software and documentation in a centralized microcomputer library.
   B. Provide research-quality microcomputer hardware.
   C. Establish a research incentive fund.
   D. Develop a user's group, open to all interested education groups for exchanging applications, knowledge, locally developed software, etc.
   E. Provide technical help in using microcomputers.

5. Support the microcomputer needs of faculty who wish to use the microcomputer in their teaching.

   A. Provide a variety of microcomputer software.
   B. Provide teaching quality microcomputer hardware.
   C. Provide demo/projection classroom facilities.
   D. Establish a course development fund.
   E. Provide technical help to the faculty on all aspects of the microcomputers.

6. Develop an effective microcomputer management system.

   A. Establish and update long-range objectives and implementation procedures.
   B. Establish and update short-range objectives and implementation procedures.
   C. Establish and clearly define the management personnel assignments and responsibilities in support of microcomputers.
   D. Generate straight-forward policies and controls aimed at enhancing the widespread use of microcomputers within the College of Education.

Summary

The College of Education at Arizona State University is actively involved in computers in education. A carefully planned computer course sequence, microcomputer laboratories, undergraduate infusion of computer application in existing courses, faculty development, active graduate students, annual microcomputers in education conferences and computer based research are all an integral part of the Arizona State University College of Education program. Curriculum, facilities, research and conferences make microcomputers in education a reality at Arizona State University.

COMPUTER RELATED TEACHING AND RESEARCH IN THE FACULTY OF EDUCATION AT THE UNIVERSITY OF CALGARY: ACHIEVEMENTS, PRESENT DEVELOPMENTS, AND PREDICTIONS FOR THE FUTURE

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HISTORY

Early Courses and Equipment

Computer applications in education officially began in the Faculty in the Fall of 1968: the first full course on the use of computers in education was in the timetable, and the first computer system in the Faculty was installed at this time. It was the outcome of two years of planning.

The course was in the Department of Educational Psychology, not because the content was particularly related to this area, but because the instructor was a member of that department. It was a graduate level course, and 12 students enrolled. Computers were not widely used in education at this time, and the course content covered most of the areas in which computers were applied. Topics ranged from teaching applications such as the PLATO and Stanford projects, to administrative tasks such as scheduling and personnel management. Also discussed were the uses of computers for simulation and the analysis of written language.

A laboratory component was concerned with the acquisition of programming skills in a high level language. Students were required not only to know how computers were being used in education, but also to create applications programs of their own.

Although there were problems in this first year, the practical aspects of computing were emphasized from the start, and have remained a very important part of all the courses in the area.

In November 1968 a Digital Equipment Corporation PDP-8/I computer with 4K 12-bit words of memory and ASR33 Teletype was installed. The interpreter for FOCAL, DEC's new language at that time, took approximately 3K of memory and several minutes to read in from paper tape.

A Small Time-Sharing System

Early in 1969 the PDP-8/I was upgraded to a TSS-8 system, the first commercially available time-sharing system based on a mini-computer. Later hardware additions brought it to a final configuration of 16K 12-bit words of memory, a 256K-word disk, 6 DEC-tape drives, and ports to support 17 terminals. This was the system used for teaching and research until the summer of 1976.

However, although FOCAL ran efficiently on the TSS-8 and was the language taught to students until a version of BASIC became available, it was essentially a problem-solving language. This meant that it was far from ideal for educational applications, particularly computer assisted instruction (CAI), towards which both course content and research were oriented. Further, Teletype terminals could not be used to produce pictures, or mathematical and scientific symbols; nor could memory space hold sufficient material for much CAI.

Hence in 1969 eight random access slide projectors were purchased, and interfaces were built to bring them under computer control. This was done in such a manner that each multi-media terminal consisting of a Teletype, slide projector, and rear view screen, appeared to be a single device to the time-sharing system, with the interface logic routing all messages to the appropriate peripheral. Thus software changes were needed only in the FOCAL language, and later in the BASIC language, and not in the time-sharing algorithms. This principle was followed with a series of multi-media terminals later brought into use.

The initial hardware was purchased because it was the best machine for research relating

to the applications of computers in teaching and learning that could be bought with the funds available. However, it in turn had a significant influence on the specific directions that research has taken. Its very existence, controlled by the Faculty and dedicated to on-line applications of computers in education, was a major factor in the development of research. For reasons such as continuity, reliability of access, and terminal response time, no such projects survive for long if they are dependent on the main university computer or on one used for administrative functions.

The relatively small storage capacity of the machine, and the ease with which terminals could be connected over telephone lines, channelled the research into school level topics where much of the material could be generated from algorithms rather than stored directly. Such research was in contrast to full university courses under development on IBM 1500 systems which had plenty of storage capacity but required terminals to be only a few feet from the machine.

Research Projects

In an area in which changes are taking place very rapidly, research and development are critical. To aid such activities the Computer Applications Unit was formed in 1970. It is a Faculty unit, not attached to any department, with its own budget and a co-ordinator, half-time in the Unit, who reports directly to the Dean. Two other faculty members, with strong backgrounds in mathematics and computing, have two-thirds and one-third of their time allocated to duties in the Unit. Support staff consisted initially of a computer manager/programmer and a secretary. Apart from the addition of a technician to the Unit in the mid 1970's the positions and their incumbents have remained constant to the present time. This has greatly enhanced the research work of the Unit and ensured continuity of long term projects.

Once the TSS-8 system was operating in a stable manner, four multi-media terminals were placed in a trailer which could be towed to local schools and other educational institutions and research and development made steady progress.

Over the years a variety of different topics have been addressed, relating to both computer assisted instruction and computer managed instruction. The most significant of these have concerned computer assisted vocational counselling (Brebner, Hallworth and Woodsworth, 1976); a management system for IPI mathematics materials; CAI, CMI and special terminal equipment for the mentally handicapped; a testing and management system for elementary reading; and a flexible management system for university courses (Brebner, Hallworth and Winn, 1980). Other projects have been in various areas of mathematics, statistics, language, and social studies, and further smaller studies have been carried out by graduate students. In general, findings have been consistent with those of similar research projects elsewhere: achievement levels using CAI are equivalent to those using other forms of instruction, but learning takes significantly less time (Thomas, 1979).

Two projects ended prematurely: the IPI management system because teachers could not handle it when graduate student support was withdrawn from the school, and the counselling system due to lack of resources to keep the data base up-to-date. The demise of the former project led to a decision never to run a project in any location where there were not people who had been trained in the Unit, a key decision which has prevented further occurrences of this kind.

Two other projects, those concerned with the handicapped and elementary reading which started in 1971 and 1973 respectively, have been particularly successful and are ongoing at the present time.

Courses on Computer Applications

Courses in the area steadily developed in the early years. The University was new and in a period of rapid expansion; program areas were being defined and established, and introducing a new area was considerably less of a problem than would have been the case in an older institution. In addition, the Faculty of Education had just moved into a large new building and ample funding was available.

Following the successful introduction of a first year graduate course in 1968, two half courses in the final undergraduate year were started in 1969, and as the field expanded a second full year graduate course was added in 1971. All of these were in the Department of Educational Psychology, and initially in its sub-division of Statistics and Experimental Design. Again, this was solely because the instructors interested in teaching the courses were in the division.

For the first few years the two undergraduate half courses had an enrollment of approximately 20 students; then suddenly numbers dropped to about two, insufficient to run them. This was due to changes in Faculty regulations, requiring students to take more courses outside the Faculty, and allowing more options from the Educational Curriculum and Instruction Department.

In the early 1970's a module on computer applications was introduced into one of the compulsory core courses of the undergraduate program. It was two hours in length, part lecture and part demonstration of a variety of CAI programs. In a later class students had an opportunity to try the programs for themselves. On the whole this was not successful; the time period was much too short for the students to grasp radically different material, and they did not see its relevance.

However, at the graduate level progress was much more satisfactory. Both M.Sc. and Ph.D. programs were set up, the former expedited by the fact that the Faculty already had an established Master's degree program, and the latter because the Department of Educational Psychology made a successful application to the Provincial Department of Advanced Education for a Ph.D. program of which computer applications was a part. The first students graduated from these programs in 1971.

Interest increased and numbers of graduate students grew to the point where the two division members were supervising up to 16 students in some years.

In such a rapidly growing field as computer applications, the content to be covered in courses quickly expands. Hence in 1975 two additional full year graduate courses were established, bringing the total number to four.

Rapid growth, while interesting and exciting in many ways, also brings problems. Course content, and consequently instructors' notes and student handouts, have to be constantly updated. It would be safe to say that part of the content of each course changes every year. Several students who have been out of the area for a few years have retaken the introductory course and found the entire content new. No allowance is made for these changes in the instructors' work load.

A further problem relates to text books and other supplementary materials for students. Computer Assisted Instruction: A Book of Readings by Atkinson and Wilson (1969) was initially used as a text as soon as it was published. However, within a few years it was out-of-date, and there was no replacement, as workers in the field realized that any text they produced would become obsolete soon after it was published. Further, for many years there were no journals or periodicals available which were specifically related to the area. The instructors relied quite considerably on internal publications they received from personal contacts at other research centers, particularly Stanford University and the University of Illinois.

Lesser problems concerned relationships with other areas in the Faculty, which required their students to take a fixed series of courses, particularly in times of decreasing enrollments and tight budgets, thus preventing them from exploring the computing area.

A Larger Time-Sharing System

In the summer of 1976 the TSS-8 system was replaced by a Digital Equipment Corporation PDP 11/70 computer. This was purchased with a grant from a private foundation and matching funds from the Provincial Government. The total cost of this system was approximately $200,000, which included six years of maintenance. These latter costs were built into the purchase price because by this time university budgets were extremely tight and the Unit could not have covered them with its operating budget.

The installation of this machine did not significantly change the direction of the Unit's research, nor did it greatly affect the content of the courses. It did, however, allow for much needed expansion of the ongoing projects.

PRESENT

Rapid Change: 1980 Onwards

Development of both research and courses had made steady progress throughout the 1970's decade, but in 1980 dramatic changes began to take place, and these accelerated in 1981. They are, of course, all related to the development of the microcomputer, and the fact that computing is not now for the elite few but accessible to and affecting everyone.

With these changes, problems in the area have changed also. Major and long-standing issues, such as the cost of hardware and the need for a dedicated machine for CAI, have faded to be replaced by the problems of keeping abreast of developments, and at the same time handling an increased number of courses and students with little increase in resources. In addition, although microcomputers make computing more accessible they still are, at their present stage of development, a backward step in many senses. This results mainly from the time lag between the development of hardware and the writing of software to bring it into effective use. With respect to software facilities, in some ways microcomputers are at approximately the point where main frames were 20 years ago.

The sudden surge of interest in educational applications of computers in Calgary can be illustrated by student numbers in the introductory graduate course. In the 1970's this course attracted approximately 15 students per year; in 1980 this number jumped to 33; and in 1981 75 students enrolled, requiring 3 sections of the course, one in an out-of-town location.

Programs and Courses

The M.Sc. and Ph.D. programs have been maintained and constitute one of the largest graduate programs in the area in Canada. Requirements for the M.Sc. include 6 full courses, a thesis, and a year's residence. Ph.D. requirements are set on a more individual basis, but always include a candidacy examination to test the student's knowledge in the general area, and a thesis. Two years of residency are required.

The residency requirements for these degrees have caused some problems in the Faculty in general, and in the late 1970's an M.Ed. degree was established. The requirements for this are 8 full courses and a final examination with both written and oral components. However, students in the computer applications area are not encouraged to take this route, there being so many research questions awaiting investigation, and none have as yet completed this degree.

An Ed.D. program is at present in the planning stage in the Faculty. This will require one year of residence, and will be attractive to those teachers who can obtain a year's sabbatical leave from their school boards.

A diploma program in computer applications is also available for those students who do not wish to take a graduate degree or whose grade point average is not sufficiently high to do so. This consists of 4 full courses, set individually for each student, but with at least two and a half courses directly in the area.

The four full year courses developed between 1968 and 1975 form the core of the graduate programs. The first course is an introductory one and is a pre-requisite of all other graduate courses in computer applications. Its content consists of a survey of uses of computers in teaching and learning applications; the BASIC language with emphasis on those features useful for CAI; drill and practice, tutorial, and simulation modes of CAI; computer managed instruction; communication codes; and major CAI research projects. Students are required to develop CAI courseware, and are encouraged to take a terminal out into a school and report on practical use of their programs. A major part of the course grade is allocated to this project. The remainder is split between labs on the BASIC language, and a final examination testing the students' overall knowledge of the field.

The second course is hardware and software oriented. Further facilities in the BASIC language are taught with particular emphasis on file structures and routines to handle various multi-media terminals. Current and likely future developments of hardware, operating systems, and languages are covered, such as microcomputer networks, video discs, CP/M, MP/M, and CP/NET. The course is graded according to work done on a set of three labs and a major project which must include use of student record files.

In the third course the emphasis is on courseware design, and the grade is based solely on a major project. This course and the second one run alternate years and the content distinction is not always clear cut. If significant developments occur either internationally or locally they are covered when current regardless of which actual course is running at the time.

In the final course a student studies a particular area of CAI in depth and is required to develop an extensive piece of courseware in the area. The project developed in this course often serves as a pilot study for the student's thesis.

The content of all these courses is evolving rapidly and is reviewed and updated at the beginning of each academic year. In all courses after the introductory one an attempt is made to introduce the students to the leading edge of research in the area.

In 1981 an additional half course on evaluation of courseware was piloted. The evaluation forms developed by the MicroSift clearinghouse were discussed, and students were required to evaluate eight pieces of courseware using the same criteria. As more courseware, both good and bad, becomes available each year it is important for teachers to be able to select that which is useful in their classroom. It appears, therefore, that this course will soon be added to the regular timetable.

A further half course on the teaching of computing is running for the first time in 1982. The major objective of this course will be to broaden students' knowledge of programming languages so that they can perceive the underlying corcepts to be taught at the school level.

At undergraduate level the two half courses have been revived in recent years, but although there was a sufficient enrollment to run the course in 1981 it was cancelled due to doubling enrollments at graduate level and subsequent lack of teaching faculty.

A fourth year undergraduate course on use of computers in special education was however, being offered for the first time in 1981. Special government funding is available for this course.

In addition to these regular courses a variety of short courses are offered in the In-service Program. The funding for these is provided through the Continuing Education Department with students paying a fee of approximately $60. These courses consist of 20 contact hours and may provide one quarter credit. As the name implies, they are aimed at practising teachers, and have proved to be extremely popular. Since the first one was offered in the spring of 1980, there has been an ever increasing demand; in the winter term of 1982 approximately 20 such courses were given, with most of them filled even before they were advertised in the schools. The number of microcomputers available restricts the size of each section to 20 students.

The in-service course offered most frequently is on computer literacy for teachers. Initially too much material was presented in an attempt to give students a complete overview. The content has now been reduced so that it covers a brief introduction to computers and their applications in education, and fundamentals of BASIC programming.

Other courses in the series include two more on computer literacy, one on computers in the basic skills, one on computers in special education, two on computers in business education, and one on computers in second language teaching. All concentrate on the use of microcomputers.

The basic computer literacy courses have been given in eight different out of town locations in southern Alberta, an area of approximately 30,000 square miles with a population of one million. Some have been given as much as 400 miles from Calgary. These sections have been particularly well received and will be continued: rural students appreciate the opportunity to earn university credit. The major problem with regard to off-campus offerings relates to availability of equipment.

The reason that an adequate response to the sudden demand for this type of course has been possible is due entirely to the comprehensive and long-standing graduate program. A group of knowledgeable, technically proficient and experienced teachers in computer applications has gradually been established and these people have formed the group of instructors teaching the in-service courses. The work is additional to their full-time teaching in the school system.

Present Hardware

While it has been possible to find instructors to cope with the proliferation of courses resulting from the sharply increased interest in computer applications, providing sufficient hardware for practical work has posed a much greater problem.

Present hardware includes the PDP 11/70 computer system purchased in 1976. This system has 192K 16-bit words of memory, an 88K megabyte disk, and a TU10 magnetic tape drive; it supports 48 terminals, 25 of which are connected from remote locations over telephone lines.

A variety of hard copy and CRT terminals are available for use with the system, including some Teletypes dating back to 1968. The laboratory for the introductory courses contains 12 G.E. Terminets. It is considered important to have a set of identical terminals to prevent unnecessary confusion for beginners. Further, it is helpful if these are hard copy terminals in order that the instructor can see an entire copy of the students' dialog

with the computer when locating problems.

Although desirable, a consistent set of terminals is hard to maintain due to the University's budgeting policy, which allows each unit to replace a little of its capital equipment each year.

The Unit also owns 15 Imsai microcomputers which fo[illegible] the base of a multi-media terminal developed and built because such terminals were not available commercially. Two of these, by the addition of extra memory and floppy disk drives, have been made into stand-alone systems.

Four Compucolor microcomputers are used in a similar manner; they can either be used as a terminal to the PDP 11/70 or as a stand-alone system.

In addition the Faculty has a laboratory containing 10 Apple microcomputers which are used for the in-service courses, but are not exclusively available for these courses as they are also utilized by other departments.

All courses are run either in the evening after 16:30, or on Saturdays. Hence, laboratories are tightly [illegible]ooked at these times, although there is free time during the day on weekdays.

Present Research Projects

While the Unit is actively developing programs in a wide range of subjects, it has four distinct projects into which it is putting its research effort at the present time. Two of these are long standing projects initiated in the early 1970's, namely CAI for the mentally handicapped (Hallworth and Brebner, 1980a) and CMI and CAI in reading at the elementary school level (Brebner, Hallworth, McIntosh and Wontner, 1980).

Work with the handicapped began in 1971 on a very small scale using one Teletype terminal. From this point, the special needs of this population with regard to CAI have gradually been defined. These include a highly structured curriculum teaching immediately relevant social living skills, the shaping of behavior rather than a tutorial approach, and constant and consistent feedback.

Specific curriculum areas addressed have been money handling skills and reading. These topics and the physical handicaps of many of the students have necessitated the design and development of multi-media terminals. Image projection is needed to display coins and bills; audio is essential for teaching reading and giving feedback to those who cannot read; special input devices are required both to overcome physical handicaps and to facilitate concept learning. In many ways the history of this project is the history of the development of a variety of interfaces to control such peripherals. The current design, which is the most flexible and satisfactory, is based on an Imsai microcomputer (Brebner and Hallworth, 1980).

The CAI project with the handicapped has led to the development of programs which have demonstrated their value in a series of controlled studies forming the basis of graduate dissertations. It has also led to the establishment, by former students, of comparable projects elsewhere. Most notable of these is the project at the University of Manitoba. Others are to be found in England, Australia and New Zealand.

The second long standing project, remedial reading at the elementary school level, began as a computer management system with on-line testing of students, to monitor progress on 329 behavioral objectives covering grades 1 to 8. The system produces three kinds of reports: an individual student report, a class report, and a total school report. Of these, the second is the most used, as it groups the students by objective and prints prescriptions both of teaching materials and enrichment activites. Some CAI modules have been added as part of the prescriptions and it is mainly in developing and testing these that present efforts are concentrated.

Another research project is concerned with the design and implementation of a complete 20 hour in-service course in CAI mode. The course is designed to help teachers cope with the needs of the handicapped students who are now entering their classes as a result of mainstreaming. The courseware is being implemented on a stand-alone Imsai microcomputer, similar in configuration to the multi-media terminal but with extra memory and floppy disk drives. This stand-alone system operates under CP/M and supports Microsoft BASIC.

In a fourth project the Unit is co-operating with the Department of Romance Studies and the Universities of Western Ontario and Guelph to produce CAI programs to assist with the teaching of first year university French courses. These programs are delivered using a

Compucolor microcomputer in one of two ways. Either the Compucolor can operate as a stand alone system with the programs accessed from a floppy disk, or it can be used as a terminal to the PDP 11/70. It is used in the latter manner when data are being collected for analysis.

Numerous smaller research projects concerned with both hardware and courseware are also on-going. These include interfacing peripherals to the current popular microcomputers, evaluating a variety of commercial packages for educational content, and developing and evaluating courseware in such topics as time concepts and tool recognition for the handicapped, and estimating skills at elementary school level.

FUTURE

In an area which is dramatically influenced by the technological revolution, it is both difficult and somewhat unwise to look too far ahead. General future directions of computer applications within faculties of education, however, are fairly clear.

Most units within a university now make use of computers for purposes of research and administration. In addition, the professional faculties must bear in mind the ways in which computers are used in their respective professions, and must prepare their students accordingly.

Insofar as the research makes use of statistical programs, as generally used in the social sciences, the computing facilities needed in a faculty of education are comparable to those required in many other parts of the university. For many research purposes, therefore, centralized computing facilities can be used.

The same may be said of the administrative applications. These can well take the same form as elsewhere in the university. Moreover, they may well follow the same history of development. For example, word processing may begin on single-user microcomputers, and progress to text processing on a network.

In catering for the needs of its students, however, a faculty of education must take cognizance of the type of computing facilities which will in the future be found in schools. It becomes increasingly obvious that these will be microcomputers, some quite small for the teaching of computer literacy, and a series of others, some of which will eventually be at least as powerful as present mini-computers. Moreover, these latter machines must be capable of delivering CAI and CMI; and within a few years many of them may be expected to be part of a school-wide or campus-wide local network with gateways to the outside world.

This developing situation produces many problems, which will find different solutions depending upon the history of computer usage and expertize within each faculty of education and its university.

At the present juncture it is envisioned that, at Calgary, most research applications which are statistical in nature will continue on the main university computer. Administrative applications, particularly word-processing, will likely begin on one-user microcomputer systems, although this may well prove to be an interim solution. Much of the teaching of computing will take place on microcomputers similar to those which will be used in the local schools, as the Minister of Education has forecast that there will be 20,000 microcomputers in schools in Alberta by 1984. However, it is also necessary to look ahead and proceed to the development of local networks so that all education students will learn about and experience the type of facilities they will meet in schools in the near future.

More specific directions are harder to predict as there are obviously many constraints which will affect the actual decisions taken. Major ones relate to the Faculty budgets and a lack of knowledgeable people in the area. To a lesser degree the policies of the Provincial Departments of Education, school budgets, and obtaining co-operation with and among school jurisdictions and teachers will play a part.

It is expected that a carrier-sense multiple-access (CSMA) local network will replace the present PDP 11/70 multi-user system. Questions are at what point in time, and which CSMA system: Nestar, Omninet, Ethernet, Ungerman-Bass or other system?

Such a network, using 16-bit processors and Winchester disks, may be expected to support the development of CAI and CMI.

With the advent of microcomputers some problems faced by researchers in the CAI field have faded while others, such as the perennial one of incompatibility of hardware and software, are still significant. General future directions relating to CAI were indicated in a report for the Alberta Department of Education written in early 1980 (Hallworth and Brebner, 1980b). So far these have proved to be fairly accurate.

While it is expected that BASIC will be the predominant applications language for some time to come, it will be important to follow developments in the use of PASCAL, ADA, languages written specifically for CAI and particularly, base languages such as C-code which ease the transferability problem.

Further key decisions relate to when to introduce high resolution graphics on a larger scale and also color; what technology to use for touch sensitive input, and audio output; when and how videotext technology, such as Telidon, can be used for CAI.

Another major problem is when to commence using videodisc technology. Both the moving sequences and high quality audio it provides are much needed facilities in the research project with the handicapped, but authoring techniques are as yet too unreliable and costly.

With regard to research projects, it is planned to continue and expand those concerned with the handicapped and with elementary reading. Areas in which other research will be initiated include high school mathematics and simulations in social studies.

In the teaching area the main thrust has been on the development of programs at the graduate level. It is important to maintain these and keep course content up-to-date. Students at this level must be exposed to current thinking and research, and course content has always been closely related to research attitudes and competence of the Computer Applications Unit. Present indications are that numbers of graduate students will increase, particularly in the M.Ed. and diploma programs.

There will be a continued high demand for in-service courses for a while and a further proliferation of these. However, this will drop off considerably when present teachers have become computer literate, or when local school boards' policies change and more in-service is provided internally.

At the undergraduate level, modules on computer applications should be introduced again into the core courses, and the optional courses at the fourth year level should also be maintained. It appears unlikely that this will take place in the near future due to budget restrictions, which are preventing acquisition of sufficient hardware and appointment of teaching staff.

The plans outlined above leave out of consideration, however, one important aspect of the situation: that of fully integrating all the computer applications required within the Faculty. Ultimately, it should be possible to establish a network which will support these disparate needs. The task of the Computer Applications Unit will be to remain current on all research and developments, and to maintain and give leadership in working to achieve this. This does not appear to be an easy role; any wrong decision is likely to impede progress considerbly.

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GRADUATE DEGREE PROGRAMS IN COMPUTER EDUCATION FOR ELEMENTARY AND SECONDARY TEACHERS

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INTRODUCTION

It has been estimated that by the year 1990, 40,000,000 Americans will need to be functionally computer literate, just to hold their jobs. If this number of people are to be trained in computer use, all the existing educational institutions must be pressed into service. To do this, large numbers of inservice teachers and new teachers must be trained to provide Computer Education. The programs described here represent one approach to training teachers to meet this need.

The author has had the experience of creating both a Master of Science (M.S.) and Educational Specialist (Ed.S.) degree program in Computer Education for teachers, at two universities – one while at Nova University in Fort Lauderdale, and now, one at Barry University in Miami. Barry University, has made a major and very contemporary commitment to Computer Education by the establishment of a school-level, interdisciplinary Center for Computer Education with plans to convert the unit to a school as enrollment and program diversity grows. The graduate programs in Computer Education for inservice teachers are but the first of many programs which will be instituted within the center.

It will be useful to describe the setting and climate in which these programs have been created and describe the Barry University program as it now exists. Some of the experience which has been gained will be shared along with a discussion of some of the factors that work for and against the establishment of a Computer Education program.

It is perhaps fitting that these programs should have developed in the center of Florida's "Gold Coast" region – Miami, Fort Lauderdale, and Palm Beach. Within the region there are over forty manufacturers of computers and other forms of "high technology". Southeast Florida may not be another "silicon valley", but it is a good start on a "silicon beach." As part of the "sun belt", rapid population growth has helped to insulate southeast Florida from many of the ravages of recent recessions. South Florida's school population has grown along with Florida's general population. South Florida even has teacher shortages in many disciplines.

Because of the way the press reports statistics, Florida's national ranking for school support appears poor, since it is usually calculated as a ratio of school expenditures **per capita**. Florida's large, retired, childless population, can creation a false impression when such statistics are used. However, if one looks at the **per pupil** expenditure, Florida looks much better. In fact, there has been a reasonable amount of money available for the purchase of microcomputers for the schools and for the inservice training of teachers in functional microcomputer literacy.

The Computer Education program described here is a M.S. and Ed.S. degree program directed specifically toward inservice teachers. The schedules are designed to accommodate working teachers. Course content reflects the plans and goals of the districts in the immediate service area. Even the microcomputers in the teaching laboratories were chosen in response to the equipment adoptions in the local school districts. However, through careful scheduling of intensive courses at vacation times, it has been possible to serve many teachers who have been able to travel here from other parts of the United States and even foreign countries.

EVOLUTION OF THE PROGRAM

By 1977, the promise of affordable microcomputers for the schools had become apparent. There were many requests to offer some coursework in microcomputers for teachers. In early 1978 the loan of four microcomputers became available. A small laboratory was promptly established and a single course in microcomputers for classroom use was offered. Response was enthusiastic among the small group of pioneering-spirited students which were attracted. Even though most of them had no immediate opportunity to use microcomputers in their own classrooms, and the course was not yet recognized for pay increments or extension of certificate, they seemed eager to pursue additional coursework in microcomputers.

We were perhaps the first university in the state of Florida to have microcomputer courses approved for certification purposes. In response to perceived needs of inservice teachers, additionally courses were continually added until a complete degree program was built. There was very little to go by, since it appeared that the only other Computer Education program around as this program was developed was the doctoral program at the University of Oregon, and it was not clear that it addressed the same needs as this program did.

After operating out of the one-room laboratory for about a year, it was found desirable to move into larger space which consisted of five offices and adjacent hallways. By now, the program had taken the form of a number of small classes, and such a space configuration was more appropriate. Two and a half years into the program, more space was required. Increased experience permitted the scheduling of somewhat larger classes, as well as considerably more individualized activity. The decision was made to move the program again – this time into approximately 6000 square feet of space, configured as three offices, two classrooms, and a large laboratory capable of holding approximately 125 students doing individualized work.

Several different formats are used within the program, all designed to accommodate fully-employed teachers. Saturday classes are the most popular followed by early evening classes. In the laboratory-oriented courses, the students began showing up earlier and earlier and staying later and later. Limits had to be set. No one could begin earlier than one and a half hours before the scheduled class time nor stay later than one hour after the scheduled end of the class period. This was a new problem.

THE IMPORTANCE OF THE ENVIRONMENT

There are some aspects of both the intramural and extramural climate which facilitate or frustrate the development of a Computer Education program. There are favorable conditions which should ideally prevail inside the institution in order that the Computer Education program can be established. Similarly, there are conditions in the community which affect the way in which a Computer Education program will develop. For example, how do the school districts recognise, use and reward the teacher trained in Computer Education. First we will consider factors which are inside the institution.

It is very important to have the support and confidence of the administration at the highest levels. This is true for several reasons. The establishment of a Computer Education program can require considerable up-front expenditures for equipment, software, supplies and renovation, as well as a great many other expenses which are difficult to anticipate. The creation of a Computer Education program can cause many institutional ripples of the kind that decrease administrative tenure. It may be necessary to educate some university administrators about the concept of Computer Education as well as the need for teacher training in this area.

The mere consideration of a computer education program can cause many territorial problems within the institution. Computer science departments, math departments, business departments, education departments, and others may all feel they have a legitimate claim to do the computer education program. A speedy resolution to this problem must be found or development of the Computer Education program can be stalled interminably.

It must be borne in mind that the Computer Education program is an **education program**, by virtue of its intended student population, wherever the program may be housed. The program must respond to the professional environment in which the teachers work and to the responsibilities which teachers bear. While content knowledge is important, it must be balanced against the techniques of **teaching**. It is important to remember that teachers are not computer science majors, and that their primary responsibilities in the schools will be to teach youngsters at the K-12 level. It may be desirable that teachers be exposed to a variety of types of equipment, however, every effort should be made to provide the majority of their training on the same type of equipment, with the same applications, and using the same software that they will use in the field.

Another issue that must be addressed is the question of whether Computer Education courses can be graduate level courses or not. If one applies the standards of a typical computer science program, many of the courses that teachers need would be considered undergraduate courses. To do the kind of work normally expected of graduate courses in a computer sciences department would require the equivalent of an undergraduate degree in computer

science. Obviously that is out of the question for teachers. This issue can be used to sabotage a Computer Education program by those who are so-inclined.

There is also the consideration of how many general education courses, foundations courses, statistics courses, and so forth, must be taken along with the Computer Education coursework to complete degree requirements. If the additional coursework required is too

great, there will not be enough room for the considerable microcomputer-related coursework which is needed to produce even minimum competency.

A Computer Education program requires resources of several kinds which most institutions are not likely to have. First, of course, is the array of micromputers, disk drives, printers and furniture which are needed. It is generally conceded that a ratio of one microcomputer to every two students is a good workable arrangement. Such a concentration of equipment can form an attraction for burglars, requiring exceptional security measures. To provide adequately for such security requires the cooperation of physical plant personnel.

Another kind of resource which is required is a collection of journals and books related to computer education. Most of the 70 or more journals and the relatively few related books will not be in the typical university library, since they are so new. To add that many subscriptions all at once, at the request of a single program, may not be possible in most institutions. One alternative is to consider them an operating expense of the program and build the collection in a location which is convenient to the students of the program. Since most of the journals have only been in production a year, or two, it is possible to have a complete collection of the literature at a fraction of the cost that would be required to do the same thing for an older field. It is, therefore, a shame not to start such a collection.

Internal factors are important, but there must be certain conditions present out there in the school districts to be served in order for the Computer Education program to be successful. The main factor is the presence of microcomputers to which teachers and their students have access. If the adjacent school districts have no microcomputers, there is little point in training teachers in the use of microcomputers.

Most school districts have a pay incentive plan that rewards teachers financially for the accomplishment of blocks of graduate credits and advanced degrees. Often, such plans recognise only certain types of graduate work as making eligible for remuneration. Typically, it must be in field or in a basic area such as math or language skills. More and more districts are recognizing functional computer literacy as being acceptable for all teachers. This can be an important factor for the acceptability of the program to teachers, and consequently for the vigor of the program.

In a similar manner, state teacher certification departments play an important part in the survival of a Computer Education program, depending upon their willingness or ability to recognize computer-related education courses for certification purposes. Even the establishment of a specific certification category might not solve this problem for all teachers.

The interaction of non-credit inservice computer training with the Computer Education program is important. If there is good cooperation, inservice can prepare teachers to enter the Computer Education program at a higher level and everyone benefits. In a worst-case situation, however, the two forms of training can compete, and overlap, creating waste, redundancy and confusion.

It is important to study the environmental factors mentioned here as a prelude to stating a Computer Education program.

THE STUDENTS

It has been interesting to observe the kinds of teachers who have applied to the programs. Originally they were virtually all math teachers. Some of them were already involved in teaching computer science as a part of the math program at their schools. Others were not certain how they would use the skills but had a feeling somewhere deep in the right hemisphere that microcomputers would eventually become more important in schools and they "wanted to be ready." Nearly all found the microcomputers infectiously exciting and were driven by honest intrinsic motivation.

There are probably several reasons for the early interest shown by math teachers. The main reason is probably that there is a legal requirement in the state of Florida for math teachers to teach computer math and computer science. Another reason is no doubt the fact that the mathematics supervisor in the local school district has a strong interest in computers. In addition, members of the Computer Education program staff have responded to requests to do microcomputer inservice sessions for math teachers for the past several years.

As the program has evolved, the interest among teachers in other disciplines has increased and now math teachers constitute only about half the applicants to the program. Teachers of the gifted were another group that showed an interest in microcomputers early. Many

teachers come out to "take one or two courses just for the orientation" – most have stayed for the program. It is interesting to note the motivations teachers reveal for why they are in the program. Many indicate that the enthusiasm of their students was responsible for their initial interest in microcomputers. Some hope to finally nail down that elusive administrative position. Quite a few have a secret ambition to write some fantastic software or courseware and "make a fortune". Others hope to escape the school scene altogether and "go into industry." Let's face it, some are merely looking for a pay increase or wish to extend their certificate and bored with the "usual kind of education courses". And then there are those who plan to stay in the classroom and feel that microcomputer facility will help them to be better teachers.

RECRUITING

Recruiting for these programs has been enlightening. Generally speaking, advertising in the open media, such as newspapers, does not work. Perhaps because these are personal computers, they and the computer education program must be introduced to people on a personal basis. Speaking to teacher groups, convention appearances, inservice presentations and workshops, and personal visits to schools have been successful in attracting applicants. Posters with tear-cards mailed to schools have been moderately successful. The national journals devoted to microcomputers in education have been good about giving space to press announcements, resulting in calls, and students, from all over the world. The best vehicle, by far, however, remains word-of-mouth from satisfied students and graduates. Another technique that we have found can be quite useful is to "follow the vendor" and advertise the program to those schools in which the vendor has placed microcomputers.

INSTRUCTIONAL STAFFING

Probably the single most severe problem and the most limiting factor affecting the growth and quality of the computer education programs is the availability of instructors. Finding both the requisite skills and a terminal degree in the same individual is very difficult. Forced to make the choice, one must opt for the skills. Typically, on-staff skills will initially be limited to one or two individuals who already have other teaching responsibilities which often cannot be readily changed.

This situation argues for an intensive staff training effort. One of the best techniques is to try to make microcomputers readily available to staff members for such personal purposes as wordprocessing their professional communications tasks. We have found wordprocessing to be one of the surest ways to "hook" a faculty member on microcomputer. Usually an interest in data base management soon follows. Somehow, before long they are programming and then they are off and running.

Adjuncts are another good source of instructors. School district personnel, particularly teachers, are the most dependable. Administrators are often too busy to do a good job. Persons working for corporations often travel a great deal and miss teaching assignments frequently.

Beware of people who are heavily involved with large computers. They typically underestimate what they need to learn in order to use the microcomputer and of course any thing that goes wrong is the fault of the microcomputer, since it is not **really** a computer. Large-computer people are alright if they are truly familiar with microcomputers or if they have made a "clean break" with large computers.

Selected graduates of the Computer Education program have worked out well as adjuncts. It would be desirable to acquire the services of graduates of other Computer Education Programs. The practice of "exchanging" graduates should be helpful for cross-fertilization of programs also.

OVERVIEW OF THE CURRENT PROGRAM

Both programs require the completion of 36 semester credits. Six semester credits of graduate work may be transferred into either program from another regionally accredited institution. Six semester credits must be earned in the completion of the students choice of a practicum, an internship or a thesis.

Within the range of things which should be included in a computer education program are several distinct skill areas into which the courses cluster. Experience thus far suggests (1) teaching computing literacy, (2) teaching computer programming, (3) producing educational software such as CAI courseware, (4) teaching specialty areas of programming such as simulation and graphics, (5) managing the computer education environment (including the selection of instructional software), (6) using the computer as a professional tool (such as wordprocessing and classroom management) and, (7) applications

of computers in teaching and the disciplines. The discussion of the courses will follow the outline of these categories.

Teaching Computer Literacy

The first two courses in the program are individualized. The fact that these courses are individualized has several advantages both for the student and for the program. The most important advantage is that it provides a comfortable, convenient, non-threatening environment in which the teachers can overcome whatever fears and anxieties they may bring to the situation. The individualized environment allows individual attention to students, making it possible to provide whatever encouragement and support seems to be required. The students are also able to begin at a time of their own choosing – they can take the time to "work up their courage". Conversely, they can get started immediately, before the urge goes away.

The individualized approach also permits us to customize the course to match the student's teaching area and interests. The payoff for the institution is that we are able to schedule better machine utilization, can make full use of whatever type of equipment we have available, and use laboratory attendants that can be obtained on a part-time basis for lower rates of pay.

The first course, Computer Literacy contains approximately 18 hours of video-tape, as well as many carefully selected readings designed to produce a "nuts and bolts" knowledge of microcomputer architecture and function. Demonstrations of computer applications and hands-on experience are also included in this course.

The second course, Operating Microcomputers is designed to equip the teacher to take a microcomputer into the classroom and use it productively in the educational process. The teacher learns how to operate the microcomputer, how to run many types of commercially available applications software such as wordprocessors, data base managers, classroom management systems, CAI courseware generators, and others. In addition the teachers learn how to perform utility functions such as initializing, and duplicating diskettes, printing, etc. After completing this course, teachers are never again heard to ask, "If I get a microcomputer in my classroom, what will I use it for?"

Both of the first two courses are "work-book oriented". There is a work-book with approximately 20 exercises each, which provide background information and direct the student step-by-step through the process of using a software package for instance. Usually, there is a product which the student must generate. The wordprocessing exercise involves the production of a resume or curriculum vita, for example. The lab coordinator assigns the students to equipment, finds the software and courseware, gets the student started and provides only as much support as may be necessary and signs-off as the student completes each exercise. The lab coordinator also provides a written evaluation of each student.

The first two courses are intended to develop the students own computer cognitive and functional computer literacy and to provide the basis for them to teach computer literacy. Students who enter with some experience may be allowed to skip one or both of the computer literacy courses.

Teachers of various backgrounds are often required to teach computer literacy. To meet this increasingly common need, we have found it necessary to institute a course called "Teaching Computer Literacy" for such persons. In this course a variety of techniques and materials for teaching computer literacy are covered. Computer literacy is one of the most difficult areas for which to prepare teachers and in which to teach because of the breadth of knowledge which the teacher must possess.

Teaching Computer Programming

After completing the first two courses, the teacher is in a better position to make a decision about which language courses to take. Most students take a series of two courses in BASIC programming followed by elective courses which have a programming prerequisite. Some students take the PILOT language and then taking a series of courses with other options. Increasingly, students are interested in taking Pascal and LOGO.
Teachers who have taken the one or more of the more difficult languages often take a course called Teaching Computer Programming.

Producing Educational Software

Many students wish to become involved in the production of educational software, particularly CAI courseware. That has become one of the specialties of the program. This is due in part to the directors experience and research interests in CAI. Because no

textbook was available for CAI courses, the director has developed a CAI text which is published by Prentice-Hall, entitled **CAI Sourcebook**.

We initially taught a single course in CAI authoring but found that one course did not provide enough time to cover all the topics and skills involved in CAI courseware production. Now, the first course is restricted to textual and numeric CAI lessons and graphics, and sound effects are reserved for the second course. If this is not done, it is very difficult to get students to spend sufficient time on such issues as the design of lesson logic and the validation process. Previously, it seemed that students spent 80% of their time producing and refining graphics and sound effects and largely ignored instructional design considerations and whether or not the special effects had any pedagogical purpose.

Teaching Specialty Areas of Programming

There are several areas of computer programming which are so specialized a sophisticated that they require separate treatment. Two that we have dealt with are graphics and simulation.

Managing the Computer Education Environment

Many teachers are called upon to be the "computer guru" in their school. The principal as well as other teachers may rely on them advice and training or may leave the computers to them altogether. Many teachers may be the ones to determine which computers will be bought, how many, how they will be housed and how they will be used. Therefore, we have found it necessary to create courses dealing with the creation of computer education laboratories, as well as the procurement and evaluation of software and hardware. The software search and evaluation courses have proven very popular and useful.

Using the Microcomputer as a Professional Tool

Teachers find the computer to be a useful tool in carrying out their professional role. Wordprocessing is useful for the creation of curriculum materials such as tests and assignment sheets, as well as professional writing of all types. Classroom management is made easier by the use of an electronic gradebook and data base management.

Applications of Microcomputers Within a Discipline

Initially, most of our students were math teachers and courses in math applications of computers were very popular. As we have gone on, discipline after discipline has requested special discipline-oriented courses so that now, very few are missing from our list of courses.

Practical Orientation

Each student must complete 6 credits in either a Practicum, Internship, or Thesis. Most Practicums involve the development and validation of a software product such as a CAI Lesson. Internships, on the other hand, involve service within a major change project such as the implementation of a district-wide data collection system, or perhaps teaching in some new or non-routine program.

FUTURE PLANS

It is clear that as the K-12 schools become more successful in teaching youngsters, there will be an ever-increasing demand for more sophistication among teachers. As equipment is introduced which has more-and-more features for less-and-less money, the range of applications will increase and the diversity of training requirements will increase as well. All Computer Education programs will have to change continuously to remain relevant to the task.

One of the directions in which this program will go is toward a greater specialization in the training of CAI authors. A part of this thrust will be toward higher level training with a more scientific approach. CAI courseware that is now being written in a large number of locations and types of settings is quite unsophisticated for the most part. In order for the potential of CAI to have the impact it can have, there will have to be an improvement in all aspects of CAI. To reach the level of training that is needed will probably require a doctoral program.

EXHIBIT A: COURSE DESCRIPTIONS OF THE BARRY UNIVERSITY COMPUTER EDUCATION PROGRAMS

CED 500 Computer Literacy (3)
An entry level course which provides a conceptual and descriptive introduction to the structure and function of computers. Applications of computers in education as well as other settings are illustrated and demonstrated.

CED 510 Operating Microcomputers (3)
An entry level course which prepares participants to use computers to implement utility software, applications software and selected tool software such as word processors, data base managers and program generators.

CED 520 Teaching Computer Literacy (3)
Cognitive and functional computer literacy are being taught increasingly at all levels of schooling. This course includes an investigation of the major issues involved and prepares teachers to plan and carry out such computer education.

CED 610 Computer Programming in PILOT (3)
An introductory course in programming which will prepare the student to code instructional courseware in the PILOT language, a powerful, high-level language specialized to CAI applications. **Prerequisite: CED 510**

CED 612 Computer Programming in PASCAL (3)
An introductory course in programming in the PASCAL language taught in a laboratory setting with extensive opportunity for hands-on experience. **Prerequisite: CED 510**

CED 614 Computer Programming in LOGO (3)
An introductory course in programming in the LOGO language taught in a laboratory setting with extensive opportunity for hands-on experience. **Prerequisite: CED 510**

CED 621 Computer Programming in BASIC I (3)
An introductory course in programming in the BASIC language taught in a laboratory setting with extensive opportunity for hands-on experience. **Prerequisite: CED 510**

CED 622 Computer Programming in BASIC II (3)
An advanced course in programming in the BASIC language, with emphasis on individual projects including advanced programming concepts. **Prerequisite: CED 621**

CED 625 Program Generators (3)
An introductory course intended to enable students to become functional with one or more program generators. Emphasis will be placed on the selection of appropriate applications for program generators and the systematic thinking required for problem-solving. **Prerequisite: CED 510**

CED 627 Teaching Computer Programming (3)
In this course, the relative strengths and weaknesses of various computer languages are investigated with respect to their pedagogical value. Participants will be introduced to the special problems and methods of teaching computer programming to individuals of varying background. **Prerequisite: one or more language courses.**

CED 631 Computer-Assisted Instruction I (3)
An introductory course in CAI with emphasis upon the principles of instructional systems design. Courseware developed will primarily be linear, verbal lessons, of simple design to permit maximum emphasis on developmental techniques and validation. **Prerequisites: one or more language courses.**

CED 632 Computer-Assisted Instruction II (3)
An advanced course in CAI which focuses upon sophisticated branching lesson designs, and employs advanced graphics, sound and simulation techniques. **Prerequisite: one or more language courses and CED 631**

CED 640 Computer-Managed Instruction (3)
An introductory course in the principles and practices of electronically recording academic performance information and using it to control academic events. **Prerequisite: one or more of the language courses.**

CED 651 Interactive Intelligent Simulation (3)
Computer simulation is a very powerful tool in a variety of applications from planning to research to teaching. This course provides an opportunity to explore the theoretical framework of simulation, examine a wide variety of applications and master some of the basic techniques of creating computer simulations. **Prereguisite: at least one language course.**

CED 652 Interactive Intelligent Graphics (3)
Computer graphics can add important new dimensions and power to human communication. This introductory course in computer graphics provides an overview of developments and encourages the student to develop skills in the planning, creation, and programming of graphics applications. **Prereguisite: at least one language course.**

CED 653 Communication and Intelligent Electronics (3)
The powerful communications abilities of microcomputers can open up the world to learners no matter what their physical location. This course explores communications technology as it relates to computers and its pedagogical applications. **Prereguisite: at least one language course.**

CED 660 Managing the Computer Education Environment (3)
All aspects of managing the computer education environment from facilities planning to equipment and software procurement to security will be covered.

CED 535 Computing Hardware
A comprehensive study of the major microcomputer brands and models. Special emphasis is given to educational applications and auxiliary equipment with educational usefulness.

CED 536 Software Search and Evaluation
A comprehensive study of the sources, features, purposes of applications software. Special attention is paid to educational software. A variety of evaluation systems are examined.

CED 660 Managing the Computer Education Environment (3)
All aspects of managing the computer education environment from facilities planning to equipment and software procurement to security will be covered.

CED 661 Administrative Applications of Computers (3)
An introduction to the range of computer applications in school administration from simple record-keeping to sophisticated planning techniques.

CED 662 Data Base Management (3)
An introductory user's course which provides a theoretical, conceptual and critical overview of data base design and utilization. Hands-on experience with a representative variety of commercially available data base managers is featured.

CED 663 Word Processing (3)
This introductory course provides the skills needed to use the microcomputer as a word processor. Emphasis will be upon professional writing and curriculum development applications.

CED 671 Computer Applications in Business Education (3)
Prepares the business education teacher to use the microcomputer in a variety of business education applications. Emphasis is placed on the identification, evaluation, and implementation of specialized Business Education CAI courseware.

CED 672 Computer Applications in Teaching English (3)
Prepares teachers of English to use the many applications of microcomputers in their teaching. The use of wordprocessing capabilities of microcomputers to create an educational environment for the teaching of writing is emphacized. Includes the identification, evaluation and implementation of CAI courseware for the development of skills such as vocabulary and spelling.

CED 673 Computer Applications in Math Education (3)
Prepares math teachers to teach computer-related content and to use the microcomputer in the math classroom.

CED 674 Computer Applications in Science Education (3)
Prepares science teachers to deal with the computer as content and to use the microcomputer as a tool in the science classroom. Emphasis is placed on identification, evaluation and implementation of CAI courseware in the science area.

CED 675 Computer Applications in Social Studies Education (3)
Prepares Social Studies teachers to deal with the computer as content and to use the microcomputer as a tool in the Social Studies classroom. Emphasis is on the use of simulation to study complex social systems.

CED 676 Computer Applications in Teaching Reading (3)
Prepares reading teachers to use a variety of the attributes of computers in the teaching

of reading. Emphasis is on the diagnostic, remedial and record-keeping strengths of computers.

CED 677 Computer Applications in the Teaching of Writing (3)
Computers present special promise for the teaching of writing. Emphasis is on the creation of a computerized environment for learning in which student writing, critique and rewriting are all facilitated electronically.

CED 678 Computer Applications in Special Education (3)
Prepares special education teachers to use the unique strength of computers for diagnosis, remediation and record-keeping in a remedial education environment.

CED 710 Practicum (6)
The practicum option requires the creation of a product such as CAI courseware or a simulation. The student must develop the product, field-test and evaluate it, and refine it into publishable form.

CED 720 Internship (6)
In consultation with an advisor, students will select an internship purpose and site. Students are encouraged to actively participate in the identification of an internship opportunity. The internship is measured, in part, as a function of time and at least 160 hours of service must be logged.

CED 730 Thesis (6)
The thesis option is provided for those students which wish to undertake a more theoretical and experimental effort within their degree requirements. A committee will be selected to supervise the progress of the student's effort.

COMPUTERS AND TEACHER EDUCATION: FROM COW TRAIL TO EXPRESSWAY

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Introduction

Since the late sixties, the University of Texas at Austin has been a very receptive environment for the educational uses of computers: a supportive university administration, an extensive Computation Center facility (dual Cyber 170/750's, a DEC-10, two DEC-23's, and IBM 370/158, and a Vector General system) devoted only to academic (research and instruction) applications, participation in a variety of instructional computing oriented projects, and a faculty eager to explore and use this technology. These factors have impacted the university community to the extent that currently over 30,000 student computer accounts, representing every academic department, are used annually.

The College of Education has been directly involved with instructional computing research and use since the late sixties. However, it was not until the advent of the microcomputer that a concerted effort was made specifically toward teacher education in both computer literacy and instructional use.

This paper traces the path of computer education in the College of Education that, somewhat like Texas, started as a cow trail and, like much of Texas, is rapidly becoming an expressway.

The Cow Trail: 1966-69

The Laboratory for Computer-Assisted Instruction, directed by Dr. Victor Bunderson, was established at the University in 1966. As its name implies, the lab's primary function was to conduct educational research related to the instructional use of computers. In the period of its existence, 1966-74, many research studies, particularly in psychology and the natural sciences were conducted. These studies in effect opened the campus for wide-spread interest in and use of the computer as a educational tool.

The Lane: 1970-72

In 1970, limited by the relatively small number of students that could be served through the facilities of the Laboratory for Computer-Assisted Instruction, programs developed in several studies were moved to the main computer at the Computation Center. This move, in conjunction with a Regional Computer Network project, had two primary effects upon the Center. First, they dramatically increased the interactive load on the Center's facilities. Secondly, through local and national publications, faculty on campus became aware that computers could be used as efficient instructional tools.

The Street: 1972-77

Participation by the university in two major National Science Foundation projects quickened the pace even more. Project CONDUIT brought the realization that instructional computing programs must not only be transportable, but also more importantly, must be educationally valid. This required participation and input from faculty of the College of Education knowledgeable in instructional design. (CONDUIT is currently a source for computer-based instructional materials that are peer-reviewed, well-documented, programmed for ease of transport and kept up to date, and is centered at the University of Iowa.) Project C-BE (Computer-Based Education) involved the design, development and evaluation of instructional computing applications in 17 academic areas, further broadening the active participation by the College's faculty in the design and evaluation aspects.

Beginning in 1973, the College of Education took initial steps toward teacher training in the use of computers. Jointly through the Departments of Computer Science and Curriculum and Instruction, the first teacher-oriented computer class was offered: "The Design and Development of Computer-based Instruction." Initial enrollment in this 3-semester hour class was 14 students.

In 1974-75, a 12 semester-hour, NSF sponsored project to train local area high school mathematics teachers was offered through the Department of Curriculum and Instruction. At this time the department also began offering a second teacher-oriented computer course:

"Computers in Education."

The Highway: 1978-80

Another NSF funded project, co-directed by faculty from the Departments of Computer Science and Curriculum and Instruction, in "Computer Science Training for Mathematics and Science Teachers," was offered in 1978-79.

The College of Education, through the Department of Curriculum and Instruction, established a Microcomputer Laboratory, initially with 8 units. New graduate course offerings become available: "The Use of the Microcomputer in Education." "Computer Literacy for Teachers," "Computer Uses in Education and Research," and "Computer Uses in Educational Administration."

Enrollment in the computer-related education courses, which had held fairly steady at the 20-30 student figure for sometime, began to show marked increases. For example, the course, "Design and Development of Computer-based Instruction," which had an initial enrollment of 14 students in 1973, now averages over 65 students per semester (current enrollment is 87 students).

Building the Expressway: 1981-present

Working cooperatively with the Department of Computer Science, the Graduate Studies Committee in Science and Mathematics Education (Department of Curriculum and Instruction), designed and began offering five (5) new degree plans:

M.Ed in Computer Science/Mathematics Instruction
M.Ed in Computer-based Science Instruction
M.Ed in Computer Uses in Educational Technology
PhD in Computer-based Science Instruction
PhD in Computer Science Education

In general, the rationale and objectives for graduate work in the first four degrees above are:

> The developing nature of science/mathematics education indicates that there are many opportunities for contributing to education, especially for people with a specialization in computer science and advanced study in science/mathematics education.
>
> The M.Ed and PhD degrees in computer-based science/mathematics instruction will qualify students as master teachers, curriculum specialists in education, and specialists for instructional programs in industry involving computer science teaching. The students will acquire appropriate decision making capabilities concerning the necessary considerations required in the acquisition of computer systems for the purposes of instructional computing. They will gain knowledge to enable them to design, develop, and evaluate software materials and programs in science/mathematics education.
>
> Specific undergraduate deficiencies, if any, and graduate courses are determined by the student's Graduate Advisor. A program of work may focus upon the elementary, secondary or higher education levels and includes such computer-related topics as:
>
> > Simulation and Gaming
> > Using Media in the Classroom
> > Designing and Writing Microcomputer Curricula
> > Microcomputers in Education
> > Design of Computer-based Instruction
> > Computers in the Modern World
> > Programming Languages
> > Computer-Assisted Instruction
> > Programming in BASIC, FORTRAN and Pascal
> > Computer Organization
> > Artificial Intelligence

A general program for the M.Ed degree includes:

> Prerequisites
>
> A baccalaureate degree, science and education for a National Council for Accreditation of Teacher Education (NCATE) approved teacher certification program,

and all general requirements for admission to the Graduate School

Education Content

15 semester hours (including master's report) of graduate level work in curriculum and instruction

Computer Science Content

9-12 semester hours of advanced and/or graduate level work in computer science

Science Content

9-12 semester hours of advanced and/or graduate level work in science/mathematics

Plus 3-6 semester hours in supporting course work.

A general program for the PhD in Computer-based Science/Mathematics Instruction includes:

Prerequisites

Unqualified admission to the Graduate School as well as the following:

A. Education (All Elementary and Secondary)

1. Undergraduate courses in education required for teacher certification by any institution accredited by NCATE.
2. A 3.0 grade point average (computed on the basis of 4.0-A) in all education courses.

B. Science Program

1. Elementary Education Candidates: A baccalaureate degree with a minimum of 18 semester hours in science, at least 9 semester hours of which must be upper-division.
2. Secondary and Higher Education Candidates: A baccalaureate degree with a minimum of 48 semester hours in science; at least 24 semester hours in computer science.

C. A 3.0 grade average in all science and mathematics courses.

D. Actual classroom teaching experience in the area of concentration at a level consistent with the degree program.

Education Content

24 semester hours (including dissertation) of graduate level work in curriculum and instruction

Computer Science Content

18 semester hours of advanced and/or graduate level work in computer science

Science/Mathematics Content

18 semester hours of advanced and/or graduate level work in science/mathematics

Educational Research Content

6 semester hours in educational measurement, statistics, and/or methods of educational research

Plus 6-9 semester hours of supporting course work.

The general objectives for the PhD in Computer Science Education are:

...to enable the student to gain competence in computer science and supporting areas (curriculum and instruction, foundations of education, educational psychology) and methods of educational research appropriate to the student's interests and with particular focus on the student's own area of research.

The PhD degree in computer science education will qualify students as master

teachers, teachers of undergraduate courses in colleges and universities, curriculum specialists in computer science education, research specialists in the field of computer science education in universities or governmental agencies and professional organizations, specialists for instructional programs in industry involving computer science training, and teachers of undergraduate courses of computer science in two-year and four-year colleges, according to their professional goals. The degree program is not designed to prepare teachers of advanced or graduate courses in college level computer science.

A general program for the PhD in Computer Science Education includes:

Prerequisites

The same as those above for a PhD in Computer-based Science/Mathematics Instruction

Education Content

24 semester hours (including dissertation) of graduate level work in curriculum and instruction with emphasis in mathematics or computer science

Computer Science Content

30-36 semester hours of computer science including at least 15 semester hours at the graduate level

Educational Research

6 semester hours in educational measurement, statistics, and/or methods of educational research

Plus a supervised internship in the area of the student's interest and 6-9 semester hours of supporting work.

There are currently over 125 graduate students enrolled at the university in science/mathematics education. Approximately 45 of these have entered one of the computer-related degree plans above.

Down the Expressway a Piece

It is apparent that, to this point in time, we are directing our attention in computer education more to the in-service teacher (especially those returning for an advanced degree), rather than the pre-service teacher. Undergraduates in the College of Education have many options open to them, including emphasis in computer science. However, not one computer science or computer-related education course is required for graduation! We anticipate this will change in the near future. Departmental discussions to this end (but not yet at the formal committee stage) are on-going. The dean and departmental chairpersons are aware of the need and are supportive. Some major questions still to be addressed, however, include what course(s) should be required and will this work be in addition to or replacement of course(s) in the current degree plan offerings? As anyone in academia well knows, such questions often are not easily resolved.

In addition, a major event occurred in April 1981. The Texas Education Agency, in its "Preliminary Report of the Committee on Computers in Education Submitted to the Deputy Commissioner for Planning, Accreditation, and Professional and Program Development," acknowledged that "...massive training efforts are required to acquaint teachers with the computer and its educational potential."

Also, a "Committee to Promote Computer Literacy for Teachers in Texas" has been established. This committee, composed of state-wide public school, college and university administrators and faculty, Educational Service Center representatives and members of the Texas Education Agency is actively promoting "computer literacy" for teachers through legislative, university and college, and community channels.

Finally, the Texas Association of Educational Data Systems (TAEDS) and the Texas Computer Education Association (TCEA) have collaborated on a "Position Paper for Computer Literacy," stating in part:

> Computer literacy is a desirable outcome of contemporary education, and it should be made an essential part of a well-balanced curriculum. Teacher training in computer literacy should be incorporated into both pre-service and in-service programs. If education is to meet the challenge of the information society during the next decade, the Texas Legislature and the State Board of

Education must take decisive action now.

This paper currently has the endorsement of 14 major teacher training institutions in the state.

Hopefully now, it has become only a matter of time until most major colleges and universities in the state will be actively addressing the issue of teacher training in computer education.

COMPUTERS IN THE COLLEGE OF EDUCATION, UNIVERSITY OF ILLINOIS

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Introduction

This paper will describe the history and experience of the College of Education, University of Illinois, Urbana-Champaign, in attempting to deal with computers in education and teacher training. Before we begin that story, however, we must establish our own perspective about teaching and change in education. We offer the following points.

1. Education evolves, it does not (and should not) erupt.

Educators are not against change. But they clearly understand that people hold intimate and personal feelings about education, and the position of education in society. Adults (even, perhaps especially, very educated ones) become slightly uneasy when school programs for their children vary significantly from what they experienced two or three decades earlier. This tension, ever present, causes practicing educators to become increasingly reluctant to diverge from widely acceptable and traditional educational programs. So, in practice, change in schools will lag behind acceptance among the public at large.

Application of computers to instruction will follow this same pattern. Computers will not be widely used in schools, either as an object of instruction or as a medium for the delivery of instruction until they are commonplace and permeate our daily lives.

2. Between the idea and the act, there falls a shadow.

Put another way, zealots of educational change frequently sound as if they trained as automotive salespersons. For two decades now we have been barraged by statements of what computers can do in education. In most cases these are statements of theory or vision. Theoretically, a computer can do "it" given proper support materials. But in order to act, teachers must have those materials at their fingertips, as well as be trained to use them. Such has not been the case. Furthermore, teacher must have materials that are educationally effective. Computer assisted instruction (CAI), for example, is only as good as the lessons that are developed for it. CAI is only a medium of instruction; it is not a method. This means that lessons must be developed that are instructionally effective, that are acceptable to students, and that work as advertised. Obvious as this may seem, it is not the situation that generally prevails today.

Most of the commercially available curriculum packages for microcomputer systems are arithmetic in content, drill in format, and elementary school in grade level (cf. EPIE, 1981). It is not clear that these curricula help students learn material they do not already know. Such curricula can hardly have a long-lasting or unique effect on education.

3. The teacher only has the time that there is.

Teachers work on a very compacted time schedule. That schedule includes no provision for extensive time to devote to personal or professional growth. Neither does it include time for extensive materials development.

Yet teachers must be involved in initial development of change is to occur. Even if CAI lessons are of excellent quality, CAI will be successful only if it is appropriately implemented in the schools. If we have learned anything from the curriculum innovation projects it is that they are only effective to the extent that they are implemented by the instructors. If computers are to be integrated into the curriculum, teachers must be involved in the development and evaluation of those

materials and the shaping of curricula that integrate them into the entire structure (Steinberg, 1977).

4. The curriculum only has the time that there is.

The total school day now is devoted to a designated set of objectives in a designated set of subjects. When large numbers of students start spending a significant amount of time on new curricula or activities, something else ceases to receive the usual level of attention. When continued over an extended period this in turn produces noticeable changes in education outcomes. These outcome changes frequently include unpredicted consequences of an undesired nature.

School curricula will respond to the impact of computer technology by adding courses with new content; courses about computers (e.g. computer literacy), courses on how to use computers as tools (e.g. word processors), courses in programming languages. Curricula will also be affected by the delivery of instruction by computers. Thus some courses will be replaced or modified by computer-related courses, perhaps at the expense of courses which are more basic to the learner's long term needs. The role of the teacher will change as some of the responsibility for instruction shifts from the teacher to the computer.

5. The buck stops at the teacher and the school.

The public at large, including many of the university-based advocates of various types of change, place the blame for unexpected or undesired consequences squarely on the teacher and the school. This is true even when the teacher or the school earnestly is attempting only to follow the prescription or visions of proponents or scholars. "Ivory tower" proponents of schooling changes seldom are at the front of the queue of responsibility when negative consequences of schooling changes begin to be observed.

The History

The College of Education at the University of Illinois is comprised of seven departments: (1) Administration, Higher and Continuing Education, (2) Educational Policy Studies, (3) Educational Psychology, (4) Elementary and Early Childhood Education, (5) Secondary Education, (6) Special Education and (7) Vocational-Technical Education. The current faculty number 120 FTE, down from a high in 1969 of 160 FTE. Opportunities to learn about computer applications to education first came in the College of Education in 1970. The University of Illinois at that time already had a long history of computer innovation and research growing out of the various ILLIAC computer projects. Also, by 1970, the University of Illinois had experienced almost a decade of computer-based education technical research and development centered around the various generations of the PLATO system. The first computer training efforts for educators were in the Secondary Education Department, with later efforts coming from Educational Psychology.

The Department of Secondary Education

The first step of computer-based education in the College of Education came not from within, but from without. A professor of engineering with extensive involvement in early efforts on the PLATO system (Dr. Bruce Hicks, now retired), requested that he be permitted to move his tenure position into the College of Education. This request was granted and Dr. Hicks assumed a position in the Department of Secondary Education. New courses and seminars were initiated with the assistance of Dr. Kenneth Travers, an interested mathematics educator. These early courses included an introduction to computer-based instruction, a computers in mathematics teaching experience, a "computers for the whole school" advanced course, and graduate seminars focusing on these themes. All early efforts were focused at the graduate level, and very quickly it became possible to complete masters and Ph.D. degrees in education, concentrating in educational applications of computers and related support knowledges such as curriculum design, theories of instruction, or evaluation of education programs. For the past several years, such graduate programs have had annual enrollments of 10-12 persons. Those who complete graduate degrees find employment about equally in (a) university teaching and research, (b) computer related administration and supervision in colleges or larger school districts, or (c) computer-based education related industries.

In 1974, a second tenure-track position for computers in education was established in the Department of Secondary Education. With this move, efforts greatly were expanded in graduate research and training, in teacher education at both pre-service and in-service levels, and in facilitating involvement of other secondary teacher education faculty to consider computers in the teaching of other subjects such as the sciences, social studies and humanities. Also expanded were efforts at training teachers to teach about computers.

This growth continues today. Extensive experience also exists in other parts of the University for computers in music education and in second language acquisition, as well as a broad array of technical courses in the Computer Science Department. The Department of Vocational Education is cooperating with the Illinois State Department of Vocational Education in its effort to provide microcomputer-based lessons in all areas of vocational education. One aspect of this project is to solicit input from teachers, to find out what lessons they would like to see implemented on microcomputer systems. Including teachers in this planning will encourage them to learn more about computer applications in education and ultimately facilitate its acceptance and integration into vocational education. At this writing, course offerings at the graduate level in Secondary Education include the following major themes.

Teaching With a Computer

a. Computer Assisted Instruction (Introduction)
b. Computers in the Teaching of Mathematics
c. Computers in the Teaching of Science
d. Computers in the Teaching of Humanities (usually centering around initial language instruction)
e. Computers in the Teaching of Social Studies
f. Seminar for Advanced Graduate Students (variable theme; reflects current concerns)

Teaching About Computers

a. Introduction to Computing for Teachers
b. Advanced Computing for Teachers
c. Alternate Computing Languages for Teachers

Courses for those training to teach about computers simultaneously present content of a computer language and necessary technical skill, curricula organization and teaching methods, and evaluation of computing objectives. These courses almost exclusively are offered in the extensive extramural teacher education efforts of the Department. On campus, the teaching of programming at this stage falls largely to the Computer Science Department. The languages involved in the extramural courses have changed somewhat over time. A few years ago, introductory programming was exclusively BASIC centered, and the common alternate language was FORTRAN. At present the introductory language either is BASIC or Pascal depending upon the objectives of the schools to which training is being targeted. Alternate programming languages respectively are Pascal or FORTRAN. Very soon another change in this menu likely will occur, with introductory programming languages becoming Pascal or LOGO, with the alternate programming language becoming Pascal, BASIC or FORTRAN (for a time), or perhaps LISP if current projections toward more intelligent computer systems and more human-like dialog software design materialize. Curricula for such courses currently are being piloted and refined.

In 1975, efforts began to extend computer expertise to undergraduate teachers-in-training. This effort centered around the theme "teaching with a computer" and was based upon the premise that to be competent with the computer medium of instruction, a person would need an extended series of intensive experiences. The vehicle chosen to carry such experiences at the pre-service level was a new conceptualization of the minor concentration. Traditionally, teachers have majored in the subject they will teach, and then have completed a minor in a second teaching field. An alternative to a second teaching field is a professional skill concentration designed to increase or enhance performance in an aspect of teaching rather than to acquire knowledge of a subject to be taught. Thus, the undergraduate minor in Instructional Applications of Computers was originated (Dennis, 1977, 1978, 1979). This program went into operation in 1977 as an elective minor for prospective teachers and continues so today. Briefly this minor consists of the following:

a. Introductory and advanced computer programming taught by the Computer Science Department. The introductory languages usually are PL/1 or FORTRAN with assembly language or Pascal being the basis of the advanced courses, depending upon choice of classes for computer science majors or non-majors.

b. Introduction to Computer Assisted Instruction, taught by the Secondary Education staff. This course overviews the design, role, and effectiveness of the major instructional computing styles. It also includes an introduction to instructional design for interactive media and heavy emphasis on evaluation and implementation of computer-based materials.

c. A Method of Teaching X with a Computer, taught by staff of Secondary Education. Sections are run for teachers of the sciences, mathematics, social studies, and

humanities (including first language acquisition, reading and literature). The foreign language and ESL departments offer a methods of teaching second languages with a computer course.

d. A computer science or applications elective. Frequently the student chooses introductory microcomputer electronics.

e. A Teaching with Computers Practicum conducted jointly with practice teaching.

The total of this experience is 20 semester hours. At this stage the minor still is offered as an elective. No computer-related requirements exist for students not electing the minor. Such plans are under consideration and are discussed later in the paper.

Early efforts relative to computers centered around time-shared mainframe or mini-computers. But as early as 1973 it was clear to the computer related faculty of Secondary Education that micro-technology would have a significant impact on educational computing. In 1974 considerable effort was directed at initial research, centering first on the feasibility of micros for a broad selection of educational activities.

In 1978, through cooperation between the Secondary Education and Computer Science Departments, efforts were initiated at establishing an undergraduate teaching major in computing for Illinois. At this writing the program still is in the approval process, having undergone seemingly countless revisions. It is not clear how extensive the subscription of the program will be, nor how it will be enforced in practice. Currently, teachers of computing courses are required by Illinois certification requirements to have only five semester hours of credit in computing to teach one course of computing. Eighteen semester hours of computing are required of those who have more that 50% of their teaching assignment in computing courses.

A variety of other computer related activities have been supported by the Secondary Education Department. These include:

1. A monograph series, called <u>The Illinois Series on Educational Applications of Computers</u>. Over fifty titles have been prepared since 1975 covering various aspects of computers in schools, courseware design, teacher education, or helpful hints to educational computer users.

2. A continuing program of extramural training courses for practicing teachers (some with NSF support). The University of Illinois at Urbana-Champaign has <u>five</u> regional centers for Continuing Education and Public Service, each with a full time coordinator. Department of Secondary Education personnel regularly conduct extramural computer course from either the "teaching about" or the "teaching with" course sequences in 3-4 of the regional centers on a rotating basis.

3. An annual offering of introductory, short workshops for schools and community colleges. Numbering about 8-10 per year, these presentations usually center on the questions:

    a. What would we do with computers if we had them?
    b. How would we choose them if we wanted them?
    c. What kind of training would we need and where would we get it?

4. A campus-based summer youth computing "camp" in operation since 1977. Currently offering two weeks of either or both of introductory and advanced computing to area students, the camp annually services about 40 students who commute daily. Plans are under consideration to expand the enrollment and curriculum of the camp, and to operate on a resident basis.

<u>The Department of Educational Psychology</u>

Educational Psychology has offered a course, Computer Use in Education, since 1971. Starting in 1980, the Department, under the leadership of Dr. Stanley Trollip, initiated computers in instruction as an area of specialization. Courses within this program provide teacher training in computers in instruction in three ways: (1) as part of the general course in the psychology of learning for teachers, (2) as courses in specific aspects of computer-assisted and computer-managed instruction, and (3) in the form of research opportunities in the field of computer-assisted-instruction.

Some teachers will be involved in deciding which CAI curricula to purchase for their schools, just as they now help make decisions about textbooks. They need to know not only how to implement the programs but also how to judge the quality of the lessons and their

potential for effective instruction. Teachers must be knowledgeable enough to see past flashy displays and catch phrases from psychology to evaluate lessons based on sound instructional design principles. Teachers must know enough to generate criteria and standards for acceptable CAI lessons. Teachers must not be willing to accept just anything in order to jump on the bandwagon and proclaim that they use computers in their school too.

Most of the masters level students in education are not research oriented but rather are teachers who take graduate courses to advance and update their knowledge for application in the classroom. Every graduate student in the College of Education is required to take a basic course in the psychology of learning and instruction. At least one of the sections of this course is taught by a staff person who is experienced in CAI and who includes in it a component in CAI. At present this constitutes 10%-15% of the course.

Teachers need to learn enough about the design of instruction for computers to enable them to help formulate and shape decisions about the kinds of lessons that should be generated for CAI. In order to do this they need to know the capabilities and also limitations of CAI.

Finally, some teachers will become part of CAI development teams, just as some are associated or principal authors of textbooks. It is no trivial matter to generate instruction for any medium; it is certainly no trivial matter to generate lessons for CAI (Avner, 1979).

The Department offers other courses with specifically CAI content: programming languages for CAI systems, instructional design for computer-assisted instruction, simulation in computer-assisted instruction, and instructional systems and computer-managed instruction. In these courses students not only learn about the subject but do projects which give them practical experience in the various areas.

The Immediate Future

At this writing, no computer experiences are required of undergraduate teachers in training at the University of Illinois. Such plans are now in the making for both elementary and secondary teachers. A major barrier to movement in this area has been "packed" teacher education curricula, brought on largely by state-mandated inclusions. A second barrier is continual budget reductions and the pressure on all departments to keep enrollments as high as possible. In such a climate, new courses to be required of students of several departments are difficult to initiate. At the University of Illinois, undergraduate teacher training programs are under the auspices of the respective content departments, with the Department of Secondary Education responsible only for the professional education course sequence. This results in a very fragmented approval process for new efforts attempting to reach prospective teachers across content lines.

It seems most likely that required computer experiences for undergraduates will come to pass not as new courses, but as independent experiences centering around demonstration of performance on a list of related objectives. Plans and a curriculum for such a teacher education component currently are in preparation, but no firm implementation dates exist. The curriculum in planning would require the average student 20-30 clock hours to complete. It would focus on functioning and survival in a computer augmented classroom. No programming would be involved. As much emphasis as time would allow would be placed on selection and evaluation of electronics materials, and integrating such materials and media with other classroom materials and media.

What We Have Learned

Based upon a decade of experience, our current positions may be summarized as follows:

1. Computer knowledge adequate to teaching about computers will grow very slowly in schools. Persons training to this level as undergraduates often will be pirated by industry (i.e., will not become teachers). In-serivce teachers do not have time available to quickly acquire training comparable to a major in computer science or even a concentration in programming. When an undergraduate takes a beginning computer science course, it is not uncommon to spend 3-4 hours a week in class plus 20-25 hours per week on personal study and practice activity (machine work). A practicing teacher cannot invest an additional 25-30 hour week for 2-4 months in learning anything new. Such time and energy are not available to the working teacher.

2. To sustain teacher interest in training, and to encourage still more commercial investment in materials development, computer activity must be permitted to proceed in the absence of "ideal" training. But the pressure of publicity

should shift more to teaching with a computer. Attempts at teaching about computers are expanding much more rapidly than levels of adequate training.

3. Attempts at training those who will teach with a computer should center around evaluation and use of existing resources. Few teachers have adequate time to train for and to execute courseware development. Those few who do achieve skill in this area are pirated from teaching by higher commercial salaries.

4. Training programs for in-service teachers need a comprehensive, developing sequence of regularly occurring experiences spread over a few years. Single day workshops create a little enthusiasm, but essentially no lasting action. Isolated courses can create limited action, but not a self-perpetuating type. And very little generalization to new action modes can be expected.

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COMPUTER EDUCATION FOR ELEMENTARY SCHOOLS: A COURSE FOR TEACHERS

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Introduction

The need for including computer education in teacher education is obvious. Computer technology practically pervades our society. Computers have been shown to be effective and efficient tools in the delivery of instruction in a variety of content areas [Thomas, 1979]. Additionally, this technology is impacting the content and processes of many disciplines [Moursund, 1981]. These circumstances present a serious obstacle to be overcome in education, particularly teacher education.

The standard teacher education model assumes considerable background has been acquired in the twelve years of precollege education. Additional knowledge is acquired by prospective teachers in content and methods courses taken as undergraduates. Graduates of teacher education programs are then equipped to interact with students from a position of superior content knowledge.

This is not the case relative to computers. Participants* (students) in teacher education programs totally lack background relative to computers. Precollege education has not, in most cases, included any computer education. In contrast, much background in language, math, science, and social studies has been acquired. Additionally, most educational media or tools (eg. blackboard, overhead projector, texts) are also familiar to prospective teachers.

Besides a lack of knowledge about computers, there is little understanding of their impact on existing curriculum. Existing methods courses do not examine issues relating to computers. For example, how does computer availability affect a mathematics curriculum which emphasizes calculation or a writing curriculum which emphasizes penmanship and the drudgery of revision?

Teacher education programs are often unable to adequately respond to the multi-faceted needs of computer education. The number of new courses necessary to provide adequate general knowledge of computers and an assessment of their impact probably cannot be added to an already full curriculum. The integration of computer education into existing courses is also hampered as current faculty lack the computer knowledge and experience necessary for such an integration.

Some solution to the computer education problem in teacher education will occur in time as both faculty and students acquire background related to computers. Until that time, it appears that teachers will be asked to "deal with" computers without adequate experience. The rest of this paper discusses an approach to solving this problem, specifically in elementary education.

The Proposed Solution

A possible short term solution to the computer education for elementary teachers problem consists of the addition of one extra required course in teacher education programs. One course is positively inadequate for even a minimal coverage of computer education. Neither is such a course adequate to provide anyone enough knowledge to "teach" about computers. One course, however, ought to allow teachers to somehow "deal with" computers and to more readily learn more about them.

It is expected that, in actual practice, elementary school teacher actions or reactions with students will invariably fall into two classes. The first consists of situations where limited teacher knowledge is not critical. With younger students a simple answer to a question often suffices. The second class of actions. then, consists of situations where more than limited knowledge would be at least helpful. In the vast majority of these cases, it is expected that students will have enough maturity to assist in the process of searching out the knowledge.

The most important requirement of the proposed course is, then, to overcome the

* Participants refers to those who take the proposed course. Student will generally refer to an elementary school pupil.

traditional notion of teacher a holder of all knowledge. This will be accomplished by having participants develop strategies for learning more about computers on their own. They will be required to practice these strategies throughout the course.

In addition to developing personal learning strategies, participants need to plan for dealing with computer related topics in the classroom. They will continually be asked to consider how their limited knowledge will affect student/teacher interactions. An expected outcome is that course participants will be able to assist their students in learning about and using computers without already having the specific information. Thus teachers will be learning along with their students.

The emphasis on learning processes (of both students and teachers) provides the basis for having non-expert teachers. Some computer and computer education content will, however, be included in the course. By the end of the course, participants will know some basics of computing. Additionally, they should have some insight into the "important" issues in computer education. Having basic knowledge of computers and some related issues should ease the transition into the role of non-expert.

Once again, this proposal is offered as a short term solution. Precollege education (and society) will eventually supply basic computer knowledge. Students in teacher education programs will have familiarity with computer applications in education. Teacher education instructors will be knowledgeable in this area also.

When these circumstances prevail, the traditional mode of teacher education will be applicable to computer education. At that time, however, the traditional mode of teacher education may have changed. In either case, this course will no longer be necessary in its present form.

Course Development Principles

There has been a basic assumption made in the process of developing ideas for this course -- teachers in elementary schools can accomplish their goals without being the ultimate source or interpreter of knowledge. Some knowledge is necessary, however, if teachers are to guide the learning of students.

Content to be included was selected for one or more of three reasons. Certain knowledge is necessary for gaining basic insight into computers and computer education. Other information is necessary if teachers are to readily, and on their own, learn more about computers and computer education. Finally, teachers need some content knowledge if they are to assist students in learning about and using computers or discussing issues that relate to computers.

Other factors also influenced the content and process of the course. Participants need to develop a "learn on your own" strategy geared toward computers and they need to practice it. "Important" issues in computer education need to be discussed. Finally, established suggestions exist [Poirot, et al, 1981] and have been considered.

Course Logistics

The proposed course is a four quarter-hour course with three hour-long class meetings for each of ten weeks. In addition, a 1-2 hour block of time needs to be reserved in the computer lab each week.

Participants in the course should have substantial background in education from coursework or experience. For pre-service teacher candidates, this would mean satisfactory completion of about half of their professional education courses. Any less background would be inadequate for reasonable consideration of computer related issues in education.

Class meetings should provide for significant student-instructor interaction. Participants will be asked to interact extensively with computers and to do outside reading and writing. All writing assignments are to be completed on a word processing system.

A variety of texts and papers are suggested for use in this course as no adequate text exists. Selections were made for the reasons suggested in the discussion of development principles. Additionally, the variety of material allows participants to gain insight into sources of further information.

The texts are exemplified by [Graham 1980] which introduces computers and their applications; by [Taylor 1980] which discusses various aspects of computer education; and by [Moursund 1981] which specifically looks at elementary education. The papers (see Appendix A and References) are needed because the texts are not comprehensive, singly or

collectively. These particular texts do, however, provide some overlap in content, thus allowing flexibility in selecting texts and assigning readings from them.

The perfect instructor for this class would have extensive knowledge and experience in computer education, elementary education, and teacher education. Such an instructor is not likely to be available. The course philosophy and structure, however, should allow this problem to be overcome. An instructor with some of the needed expertise can model the behavior desired of course participants by learning along with them.

Class size is a critical issue in this course. The number of participants is restricted by the two factors - availability of equipment and the need for class discussion. It has been suggested that not more than two people can effectively use a single terminal [Ahl, 1981]. Thus, there should be no more students than twice the number of primary systems (discussed below). This restriction may be surmountable if the instructor can schedule more than one lab session. The second restriction is harder to overcome. Individual instructor differences may allow more or fewer students, but it is likely that 15-25 students is the maximum number than can be easily involved in class discussions.

The final area of course logistics deals with the availability of hardware and software. Two different hardware systems are necessary, a primary and a secondary system. The primary system will be used most extensively, but the secondary system is necessary to allow the participants an opportunity to assess their ability and procedures in learning to use new systems. The number of secondary systems is not critical, so long as participants can all easily use one of them within a 2-3 day time period.

A relatively extensive collection of software is, of course, necessary. During this course, participants should use:

1. a word processor or good text editor
2. one or more administrative packages (grades, attendance, etc.)
3. several drill and practice programs for various content areas
4. several educational games
5. several simulations
6. one or more programmed instruction and management systems (tutorials that record student progress)
7. a LOGO system

Course Organization

This course has three content components, each with several subdivisions. The general aspects of the components are discussed below, while a detailed outline is presented in Appendix A. Some discussion of process goals is also included and provides additional insight into the course philosophy.

Content

The first of the three components involves basic knowledge. Included here are:

an introduction to computers and how they work;
a survey of computer applications in society and some related issues;
a survey of the "classic" applications (drill, programmed instruction, games, simple simulations) of computers in education;
and some instruction in reading programs.

The goals of this component are to impart basic knowledge and to reduce the mystique associated with computers.

Component two consists of a more in-depth treatment of computer applications in education. This treatment has two approaches. First, specific types of applications are examined and discussed from a general point of view. Discussion here includes why, when, and how issues of computer applications. The second aspect focuses on content areas and how computer applications might enhance their curriculums. A primary goal of this component is to represent computer applications to education as being multi-dimensional. For example, in language, computers can provide drill in vocabulary and also significantly alter the process of writing through the use of word processing systems. The combination of the two approaches is necessary for a complete picture of the applications.

The third component deals with other (often neglected) issues related to computer education. A variety of such issues exist and any list of them is likely incomplete. They include psycho-social effects on students, philosophical approaches to computer education, and generally a critical analysis of the claims for computer education. Some further insight into specific issues can be gained from Appendix A and [East 1982].

Again, a primary goal is to emphasize the breadth of computer impact on education. Additionally, this component provides a basis for dealing with computer education in the future.

Each of the three components will have actual computer experiences integrated into them. By the end of the course, participants will have seen and used programs in each of the classic application areas. They will also have used a support or management system and become relatively comfortable with a word processor. These experiences, and related discussion, are expected to familiarize participants with computers so they will be significantly less hesitant to use them with their students, when appropriate.

Process

As noted earlier, a single course cannot begin to provide a teacher with all or even most of the knowledge and skill needed to play the role of expert, even with elementary school students. The substitute role of one who knows how to find out is being advocated. Toward this end, each component above will include an emphasis on two processes.

First, participants will be expected to develop strategies for extending their own knowledge or skill. This will be accomplished by having them learn on their own and by specifically discussing what this process involves. Individual differences are to be expected and should be capitalized on by the instructor.

The second process involves planning how student interactions might proceed. This includes discussing the effect of limited teacher knowledge and the teacher's role in assisting students to learn on their own. As with the processes used by participants, elementary students are expected to have individual differences. The lack of a "right" process should be stressed.

The class discussions and computer interactions form the foundation for accomplishing these process goals. Other activities are also important. For instance, participants will be required to keep a notebook throughout the course. Included in the notebook will be knowledge gained, sources of more knowledge, processes used in gaining more knowledge, processes necessary for using computers and programs, and suggestions for aiding elementary students in these processes.

These suggested components, experiences, and processes have been chosen in an effort to achieve three goals. Participants should end the course with an awareness of their limited knowledge. They should also have confidence in their ability to learn more, whether it be knowledge about computers or the need to use a new system. Finally, participants should have outlined some method for incorporating the above into their own interactions with students.

Participant Grading

Grading serves two purposes. It encourages students to complete, in a timely fashion, the course assignments and it points out the aspects of the course deemed important by the instructor. Suggested elements of grading include exams, reviews of papers, a term paper, a notebook, and class participation.

One or more exams can be given, covering the knowledge components of lectures and readings. The participants can be lead to develop strategies for finding information and information sources by being required to submit reviews of papers. Each review should be for a paper from a different source so participants have a broader knowledge of information sources. A term paper can be used to allow students the opportunity to synthesize course content and process. Again, all written assignments should be completed on word processing systems.

The notebook is considered a key element or product of the course. In addition to evaluating it at the end of the term, intermediate examinations of the notebook by the instructor can provide the participants with feedback as to completeness and direction in its compilation.

Some Implementation Questions

This course in currently in a development stage. Anyone considering the implementation of this course should ensure that a reasonable course evaluation effort is included. Some suggested evaluation questions are discussed below. In addition to being useful to implementers of this course, the suggestions are useful to anyone reading this document.

The first suggestion is to separate consideration of content/process questions from that

of goals/philosophy. Thus one should ask, "Are the goals and philosophy appropriate?" If the answer to this question is yes, then consideration of the selected content and processes should proceed. If not, then it is useless to proceed.

The second suggestion is that the course evaluation concentrate on process and not on knowledge imparted. That is, the participants' perceptions of their own learning processes and ability to deal with computers is more critical than is the mastery of computer content.

An appraisal of the instructor's perceptions is also necessary. In this case, several points are worth considering. First, how successful was the emphasis on the reading of programs? Did participants manage to become acquainted with programs enough to aid students who read or write programs? Was the knowledge component of the course adequate for considering computer education issues? Were participants able to use their processes for acquiring information on their own? Was the switch to the secondary system aided by preplanning?

Finally, in the evaluation of content of this course, one must realize that it is impossible to be comprehensive in the time allotted. Some standard computer content has not been included. When examining content selection, the reader (implementer) is asked to carefully weigh the relationship of content and course goals.

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Detailed Course Outline

I. Course Introduction (1 day)
   A. Goals
   B. Philosophy
   C. Procedure
   D. Requirements
   E. Sources of information (discussion)
      1. for adults
      2. for children

II. Introduction to Computers (2-3 days)
   A. Class discussions/lectures
      1. general capabilities & configurations
      2. history
      3. data/information processing
         a. binary representations
         b. computer processing
      4. sources of above knowledge
      5. discussing above with students
   B. Lab activity
      1. participants use system, given only its location and documentation - instructor provides aid in finding info., not info. itself
      2. what's involved in using system?
      3. problems elem. students would have?
   C. Outside class
      1. read 3-4 chapters on computers
      2. enter in notebook
         a. knowledge gained
         b. "tentative" system use process
         c. "tentative" hints on dealing with elem. students

III. Computers and Society (2-3 days)
   A. Class discussion/lectures
      1. computer applications in society
      2. computers & society issues
      3. discussing above with students (when/where issues likely to arise with elem. students)
   B. Lab activity
      1. use word processing system
      2. instructor provides aid in finding out, not actual directions
   C. Outside class
      1. computers in society chapters
      2. enter in notebook
         a. knowledge gained
         b. more dealing with students hints

IV. Computers and Education (2-3 days)
   A. Class discussions/lectures
      1. classic applications (history/types)
      2. locating/evaluating software
   B. Lab activity
      1. use a management/support system
      2. what's involved in learning/using it
   C. Outside class
      1. read selected papers
         a. Thomas (or similar article)
         b. 2-3 evaluation checklists/procedures
      2. begin running each type of CAI program
      3. enter in notebook
         a. CAI knowledge
         b. locating/evaluating software processes
         c. initial feelings about CAI
         d. using new packages - process

V. Reading programs (2-3 days)
   A. Class discussions/lectures
      (read programs - simple to complex; use
      CAI programs as examples)
   B. Lab activity
      1. use programmed instruction & management
         system (instructor points to info. still)
      2. what's involved in using package
   C. Outside class
      1. run example programs prior to class
      2. skim language reference
      3. notebook entries (as appropriate)
      4. paper #1 review (done on word processor)

VI. Computer Education (3-4 days)
   (a closer look)
   A. Types
      1. support
      2. games & simulation-games
      3. drill & practice and single topic tutorials
      4. "true" simulations
      5. PI&M systems (tutorials with record keeping)
   B. For each type
      1. why/when/how to use
      2. limits imposed by teacher knowledge?
      3. side-effects issues
   B. Lab activity (no formal activity - continue
      examining various applications)
   C. Outside class
      1. readings
         a. selections from Moursund
         b. selections from Taylor (Suppes)
      2. continued use of PI&M system
      3. notebook entries as appropriate
      4. paper review #2

VII. Computer Education from Content Area Perspective
   (3-4 days)
   A. Class discussions/lectures
      1. using computers in: math, language,
         science, social studies
      2. for each of above
         a. goals of curriculum
         b. why/when/how computers useful
         c. advantages/disadvantage of computers
         d. other issues?
   B. Lab activity - (no formal meeting - continue
      using CAI programs)
   C. Outside class
      1. readings
         a. Moursund selection
         b. Taylor (Dwyer & Papert on math)
      2. transfer to a new system (devise a plan)
      3. notebook entries as appropriate
      4. paper review #3

VIII. Adapting to New System (1-2 days)
   A. Class discussions/lectures
      1. what's involved
      2. helping students use a (or a new) system
   B. Lab activity (LOGO)
   C. Outside class
      1. have tried plan for transferring to new
         system
      2. notebook entries
         a. transferring to new system
         b. helping students do so
      3. paper review #4

IX. Other Issues (7 days)
   A. Class discussions/lectures
      1. to program or not to program
         (Taylor: Luehrmann,Dwyer,&Papert, Moursund)
      2. "higher" level computer education
         (Taylor: Dwyer&Papert)
      3. COMPUTER education vs computer EDUCATION
         (Garson, Cunningham)
      4. effects on students
      5. review, synthesize, evaluate course
   B. Lab activity - no formal meetings
      (continue examining programs and LOGO)
   C. Outside class
      1. Readings (see under A)
      2. notebook entries as appropriate
      3. paper reviews #5,#6
      4. term paper

THE CHALLENGE OF COMPUTER EDUCATION TO TEACHER EDUCATION --AN AUSTRALIAN PERSPECTIVE

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Two Responses to the Challenge

This paper reports the development of computer education at two institutions which differ markedly in their roles within teacher education; firstly, at Victoria State College - Toorak campus, and secondly at Monash University, Melbourne, Australia. Victoria State University - Toorak Campus is a teaching institution primarily concerned with elementary teacher education; whilst the Faculty of Education at Monash University has twin emphases of teaching and research in education with a major concentration in secondary education.

Part A: ELEMENTARY EDUCATION

Context.

The Toorak campus is one of four post secondary campuses spread throughout the suburbs of the city of Melbourne which have been recently joined to form Victoria State College, a college of 5,000 students. The focus of Victoria State College is teacher education at all levels (Grades K-12), business, and art and design schools. Victoria State College is only one of the six institutions within the city which have major programs in teacher education, serving the needs of the 3 million population of Melbourne.

The major emphasis of the Toorak Campus, which serves approximately 1300 students, has always been the pre-service, graduate and inservice education of elementary teachers. At the Toorak Campus itself, approximately 200 students complete the 3 year pre-service elementary education program each year, with several hundred practicing teahers involved with fourth year and further studies.

Within Australia, elementary teachers typically undertake a three year pre-service program at a campus such as Toorak, where education studies comprise two thirds of the program with the balance being general studies in the traditional tertiary disciplines. Education studies include method classes in each of reading, children's literature, mathematics, science, social science, art, music, health and physical education. One major assumption is that the beginning teacher is likely to undertake a generalist classroom role, with responsibility for most of the grade's program. Elementary teachers must then teach for at least one year before returning for four year studies, usually part-time. In addition to the fourth year program, further one year programs (graduate diplomas) with specializations in educational technology, music, reading and childrens' literature are in operation.

Initial Impact

Since 1977, there has been a gradual evolution in curriculum development incorporating the computer, primarily in three subject areas (Mathematics, Science, and Educational Technology). In each case changes have occured both in the discipline and method classes with respect to objectives, content and teaching strategies. Until now, the focus has been incorporation within the existing structure and classes rather than the development of new separate classes in (say) computer literacy.

In 1977, a mini-computer with card reader for batch processing, a terminal for interactive programming and a printer were installed. Since then microcomputers have been progressively purchased. At the present time there are eleven Apple II and two TRS-80 microcomputers with five associated printers, available to staff and students. One Apple II is housed in the Campus Resource Centre for permanent access by students. In addition, six terminals have been recently installed on-line with a large main-frame computer on another campus.

Every student undertaking a mathematics elective general study class since 1977 has studied at least a 20 hour unit in computer programming in BASIC. In this manner, one third of the elementary education students each year completed such learning units, these units forming approximately one quarter of the mathematics subject class time. This arrangement was recognized as not being ideal as it is agreed that:

> Teaching programming within Mathematics tends to limit students' appreciation of

computer applications to those which are predominately mathematical,...and it maintains the false implication that computing power is only available to an elite mathematical few. (McDougall, 1980, p. 21)

About this time (1977), workshops and units were developed for use within mathematics method classes concerning the place of the calculator as an aid to mathematics teaching. Throughout these units in each year of the program, the objectives centered upon awareness of and skills in using hand-held calculators, and aids such as Little Professor and Dataman, in elementary mathematics programs. Students were generally very hesitant about the use of calculators in schools.

In the Science general study program students used microcomputers as data processing units to store and analyze data from experiments in the biological and environmental science disciplines. In addition, Educational Technology classes have used microcomputers as aids in evaluating and developing Computer Assisted Instruction packages emphasizing the principles of effective instructional design.

Changing Focus.

In the past two years the emphasis in computer usage has moved from the development of mostly programming skills (in BASIC), to an increasing awareness of other elementary teacher needs. These other needs include sensitivity to computer impact upon society, skills in software evaluation, experience with another language (LOGO), a language which holds great promise for use with elementary school children.

Currently, within the three year sequence of Mathematics method classes there are workshops concerned with technological change (automatic warehousing, supermarket scanners, robots on automotive assembly lines and the like), using videotapes such as 'Now the Chips are Down' (British Broadcasting Corporation) and a range of other documentaries as the stimuli. Similarily the Social Science methods class has incorporated simulation/discussion workshops relevant to the use of data banks, invasion of privacy and the balance between the rights of society and the individual.

The College has now purchased software such as the Milliken mathematics series, other drill and practice programs concerning units in science, vocabulary and grammar in English, and several simulation packages for social science and science. This bank of software has enabled students in method classes to develop skills in evaluation of commercially available packages. Please note that in this program classes in all method areas are compulsory for all elementary education students. Some students have been able to use College hardware and software as part of student teaching requirements in local schools with enthusiastic results. Lastly, within mathematics method classes at the second and third year level, the possibilities of LOGO have been demonstrated and begun to be explored with students, and some students have developed lesson material incorporating LOGO.

Alongside these developments in the total program for all students, mathematics majors have continued to study programming in BASIC. There has been an addition of a further 20 hour unit in their final year in which the total emphasis is the project development of programs for elementary children in the topic areas of mathematics, science and language. Furthermore, two APPLE II microcomputers are now used more extensively throughout the science general study sequence both for data processing and with interactive simulation packages modelling environmental issues.

The net result of these initiatives is that all elementary education students receive the set of what may be termed "computer literacy" experiences described above in the mathematics, science, social science and educational technology method classes. In addition one eighth of them study programming in BASIC for up to 40 class hours, a further one eighth develop more extensive programming skills over an 80 class hour sequence, and at least another one eighth of the pre-service student body develop skills in using the computer in science. It has been observed that students have been generally more responsive to the notion of computer use in schools than calculator use - a reaction faculty find most interesting and worthy of investigation.

The Needs of Practicing Teachers.

Elementary teachers in schools are seeking assistance in rapidly increasing numbers from the College regarding computer purchase and use. This assistance has been provided both informally and formally by the Toorak Campus faculty via means of individual faculty, short-term non-credit inservice courses, and fourth year and further studies formal programs.

Inservice initiatives have included the conduct of short courses (e.g., 6 weeks x 1 night)

for total school staffs by some science and mathematics faculty and the participation of a mathematics faculty member in the Computer Education Advisory Committee for the State Department of Education, wherein the faculty member has led several one day conferences for elementary teachers. Furthermore in 1981 some faculty led workshops at the annual conference of the Computer Education Group of the state of Victoria, a conference at which one of the keynote addresses was given by Seymour Papert.

Practicing elementary teachers who undertake a wide range of fourth year degree programs now have a choice of classes featuring elements of computer education. Formal classes in Introductory Computer Programming in BASIC (45 hr) are conducted twice a year. Typical projects involve the development of a learning package appropriate to specific groups of elementary school children. The Educational Technology program also includes two other semester courses, which emphasize the development of a curriculum package, using the computer as an aid to instruction. Both fourth year Science and Mathematics curriculum method classes incorporate the evaluation of software, its impact upon curriculum, and the use of LOGO that is now available.

Plans

The total Victoria State College faculty is currently refining a proposed graduate program in Computer Education, with an emphasis upon elementary and middle school education. This proposed graduate two year part-time program is a joint effort of several faculty units on the Toorak Campus, along with business school faculty from another campus and education faculty from other campuses of Victoria State College. Students will complete eight semester units from a range of classes such as Computer Literacy, Evaluation of Software and techniques of Implementation in the Curriculum, Computer Programming in BASIC (or LOGO), Structured Programming (PASCAL), Applications in Mathematics and Science education, Using Statistical Packages (e.g., SPSS), and a development Project.

Issues.

One of the greatest problems facing faculty at an institution like Victoria State College, which emphasizes a high quality teaching program, is that of time to devote to the development of new major expertises in such situations. A faculty consensus concerning goals and directions of change, at least at the unit level, becomes most important.

Secondly, the paucity of effective software to illustrate the potential for computer use in schools is of real concern, although this situation is slowly changing.

Another aspect of which faculty have become more aware is the latent anti-technological bias of many elementary education students. Whether this orientation is a function of their predominately humanities high school and/or age-old sexist attitudes is a debatable point. Many of these female prospective elementary teachers are, however, most reticent about the role of machines in education.

A further complication is that local teachers in elementary schools are not using either calculators or computers in their programs. Thus during student teaching experiences our pre-service students are not observing effective role models regarding the use of these aids. Ferres (1981) reported that very few Grades 4 to 8 classroom teachers in a sample of 46 schools from a geographical zone in Melbourne, were using calculators as one of their current instructional strategies. Only approximately one half of the Grades 4 to 6 teachers indicated support for future use of the calculator in Grades 4 to 6, given certain qualifying conditions. The teachers surveyed also stated that whilst one half of the grades 7 to 12 schools possessed microcomputers, they were generally not used below Year 9, and not one of the 33 elementary schools surveyed had purchased a microcomputer at that time.

A College of Education, with a major focus in elementary education, and operating in such environments, must be cognizant of these prevailing attitudes and develop its programs accordingly.

Faculty Development.

Australian teacher education is undergoing similar pain with respect to declining enrollments and resources as American colleges. This is occuring in an era when technological change in the society outside of schools is rapidly making much content and teaching strategies within colleges of education questionable and possibly outdated. Present faculty are being forced more than ever before to generate curriculum change, rather than possibly rely upon the influx of new faculty.

Faculty from the Toorak Campus of Victoria State College endeavor to participate fully at a range of both Australian and overseas conferences. The benefits are both information

and much inspiration, as per Seymour Papert's illuminating address regarding his "turtles" and "sprites" at the Melbourne 1981 conference of the state Computer Education Group. The head of the mathematics and science units has been a regular visitor to the University of Iowa for the past several years to discuss current trends in the use of technology in schools. The use of sabbatical leave can be most crucial in this respect too. I am currently studying with Dr. Moursund at the University of Oregon, whilst next year another member of the mathematics education faculty will study computer impact upon curriculum at an English university. As faculty expertise is increased, education faculty will be able to make a more knowledgeable response to the challenge of computers as aids to learning. In addition, there will be some learning too for those computer science faculty who are unaware of the purposes and struggles of modern public school education. Then and only then may a true partnership between educationists and computer scientists (and society?) be forged to create processes by which technological innovations which benefit student learning, are implemented in schools more effectively in the future.

PART B: SECONDARY EDUCATION

MONASH UNIVERSITY -- ANOTHER RESPONSE TO THE CHALLENGE.

Context.

Monash University, Melbourne, is a widely respected major university within Australia, noted particularly for the strength of its education faculty in the fields of experimental design, measurement of attitudes, statistics and research. Thus the Faculty of Education has for some years had extensive system of terminals on line to the Burrough's main frame computer in the University Centre.

Grades 7 to 12 teachers (known as Secondary Teachers in Australia) typically complete a three year program in their discipline and then enter a one year education diploma program to complete their pre-service training. The Monash University Education Faculty provide education foundation courses and the complete range of method classes for the prospective secondary teacher. After teaching for at least one year, teachers may complete a fifth year of study (Master of Educational Studies). A Masters' degree in Education and a Doctorate of Philosophy in Education are also available. (It should be noted that some elementary teachers also undertake the graduate programs at Monash University.)

The Recent Past and the Present.

In 1980, the first appointment in Computer Education was made when Anne McDougall was named to a joint lectureship in Computer and Mathematics Education. In the past two years an impressive array of courses have been developed and implemented at all levels, for both pre-service and graduate students. At Monash University, therefore, the emphasis has been upon the development of a comprehensive graduate degree program, with the integration of computer education sections into traditional courses occurring to a lesser extent.

At the Diploma in Education level for pre-service secondary students, two new courses are (1) Introductory Computer Studies and (2) Methods and Practices of Teaching Computer Studies. The first course caters for students from all method areas and may be described as a computer literacy course. By contrast, the second course is intended to prepare students for teaching computer studies courses ranging from computer awareness courses at Junior Secondary levels to Year 12 Computer Science courses. The state of Victoria has recently finalized the preparation of its first ever Year 12 Computer Science courses, and accompanying texts have been produced (Montgomery and Juliff, 1981).

In a paper presented at the Third World Conference on Computer Education (McDougall, 1981), Anne McDougall reflected on the experience of the first Computer Studies Methods course during 1980. The paper addresses the particular problems arising from the fact that this generation of student teachers cannot draw upon their own school learning experiences. McDougall also discussed the lack of established texts and materials, the difficulties of class organization to ensure equitable access, and the recognition that even among their peers there were great differences in the confidence of using equipment and very disparate rates of learning programming. These factors, she believed, could all be turned to great advantage in reminding the student teachers that they must use teaching strategies sensitive to the needs and differences of their secondry students.

Facilities now available to students include two TRS-80's and four APPLE II microcomputers, one Intercolor minicomputer, two Turtles (for LOGO) and various graphics tablets and printers. The benefits from having the services of a very good technician are reported to be immeasurable.

At the graduate (fifth and sixth year) level, five new courses are now offered within the Faculty of Education, namely:

1. Computers in Mathematics Education.
2. Technology and the Administrator (and in alternate years),
3. Data Processing and Information Retrieval.
4. The Impact of Computer Technology on Education (and in alternate years),
5. Development of Computer Programs for Education.

Each course is of a half year semester duration with a class time of 3 hours per week.

Computers in Mathematics Education examines computer-based techniques now possible in the teaching and learning of both elementary and secondary mathematics. Courses (2) and (3) aim to raise the awareness of administrators of the possible roles of technology in modern schooling and administrative practices, and how to implement the associated organizational changes. For example, it is intended that students will become familiar with microcomputers, word processors and office systems, and furthermore consider techniques for the establishment, storage and processing of data files; use standard statistical packages (e.g., SPSS); and use on-line information retrieval facilities (e.g., ERIC). The Impact of Computer Technology class is intended to examine the Implications in educational settings of techniques such as information acquisition, storage, and retrieval; research findings concerning the effects of computer-based techniques in instruction; and possible influences on curriculum development for Computer Studies courses. The Development of Computer Programs class will focus upon techniques and problems in the design, implementation and documentation of programs.

This range of courses is a first, but well balanced, attempt in providing a selection of courses in Computer Education for teachers. The development of new courses, particularly at the graduate level, has been an extensive response to the challenge of computer impact upon schooling.

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COMPUTING AND EDUCATION AT THE UNIVERSITY OF MARYLAND

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The University of Maryland has a large College of Education-1600 undergraduate students (roughly equal numbers in special, industrial, and early childhood-elementary education and a smaller number in various secondary subject areas), 1750 graduate students (most part-time students, divided among programs in seven departments), and a faculty of 150 (including many joint appointments in other academic departments). For the past ten years there has been some very modest work in educational computing. Since 1975 all undergraduate students in the mathematics courses for special, early-childhood, and elementary education have learned rudiments of BASIC programming and its uses in elementary mathematics. Typical work includes running game and demonstration programs and writing simple looping programs to search for primes, pythagorean triples, or a max/min point for some function. The effect of the experience is usually little more than a first taste of what computers do and what is required to communicate plans to the machine. Since 1973, the secondary education students majoring in mathematics have been required to take at least one computer course - usually FORTRAN programming. No other undergraduate education program requires work in computer science, and until the last two years, no undergraduate course in the College of Education made more than passing mention of educational potential in computing.

For graduate students in education, required and potential contact with computing has also been very limited. For nearly ten years most have used canned statistical programs in a batch mode. A few have taken the sporadically offered computer assisted instruction course, usually concentrating on learning and use of a CAI authoring language. In mathematics education graduate courses some small fraction of curriculum analysis has considered the potential of computing for effective teaching (e.g., PLATO demonstration or study of material such as the CAMP or Man-Made-World programs that used computing to illuminate mathematical ideas) and for changing curricular emphases (e.g., numerical approaches to calculus).

The explanations for this low level of activity relating computing to education are understandable and probably common to most colleges of education: few interested and knowledgeable faculty, few impressive or accessible models of computing applied to instruction, university facilities poorly configured to develop or use education software, and widespread belief among the teacher clients of the college that "We won't get computers in our school for a long time." In the past 18 months all of these conditions have changed radically at the University of Maryland. As a result, the instructional, developmental, and research programs of the college have been transformed to give much greater attention to computing.

Faculty Development-The critical prerequisite for genuine integration of computing into teacher preparation programs and school curricula is broadened range of faculty who are computer literate. At Maryland the first steps in this direction have been taken by individual science, mathematics, and statistics faculty. Using personal computers, they began exploring the educational possibilities of the equipment and the emerging software. They incorporated their knowledge into appropriate courses - transforming the moribund CAI course into a survey of educational computing and demonstrating ways to use computers in the classrooms of their special subject interests.

To spread this acquired knowledge to other faculty, the college and several departments have conducted a series of faculty development workshops - reaching well over half the college faculty. One format for such workshops has been a half-day session combining demonstration of hardware devices and sample instructional software with some "hands-on" time to help potential faculty users become comfortable with operation of the micro-computer at the level of using prepared programs. On several other occasions computing has been one facet of two-day all-college faculty development days. The first included a series of presentations on uses of computers in research - computer graphics for testing spatial visualization or computer presented tasks in a study of reading work attack strategies, for example. The second all-college faculty development session looked

at futurist prospects for education and included description/analysis of various information technologies. The goal of these sessions was to acquaint faculty with educational prospects for technology and to stimulate broad program development and research initiatives. As a result of these initial efforts, we now have many more faculty actively studying and using computers in education. Many have joined the regularly offered course surveying educational uses of computers. Further, the support for computing as part of undergraduate and graduate programs has grown markedly.

Program Development - The transformation of interest among faculty into course, program, and degree offerings has, understandably, proceeded more slowly than faculty awareness efforts. Since all College of Education faculty using computers are essentially self-taught, with knowledge acquired to meet their personal interests and needs, they sought advice of several Computer Science faculty with interests in education. A joint committee - representing the Departments of Computer Science and Curriculum and Instruction - has worked during the past year to define and develop course offerings that would meet the needs of the various constituencies the college serves.

Exploratory course offering during the past several years reflected the subject matter interests of specific faculty - a mathematics educator offered a course in uses of micro-computers for teaching secondary mathematics, a science educator offered a course on interfacing of micro-computers and laboratory equipment, and the original CAI course gradually evolved into a survey of computing but still attracted graduate students concentrated in science and mathematics education. Despite the trend leading toward special focus courses of the type "Computing and Education in Subject X," the program development committee chose a different plan for integration of computing into College of Education course offerings. The decision was to offer a sequence of courses that would bring together people with diverse academic specialties and school level interests. An informal assessment of student needs and faculty expertise led to development of three core courses (all currently being offered), a fourth special topics research seminar (not yet offered), and the option to subject areas for developing courses that meet special needs.

Course I. Introduction to Computers in Instructional Settings

Goals: Survey of instructional uses of computers, available hardware and software, and elements of programming (BASIC).

Main Topics:
1. Utility programs with general application to instruction (grade books, word processing, data base systems).
2. Computer hardware tools (computers and peripherals like printers, graphics displays, light pens, transducers) and comparison of brand characteristics.
3. Demonstrations and critical analysis of major modes for use of computers in education (drill and practice, simulation, testing, artistic expression, problem solving).
4. Elements of programming

Course II. Applications of Computers in Instructional Settings

Goals: An in-depth analysis of strategies and techniques for using computers in instruction, including survey of psychological, philosophical, and practical factors in educational applications of computers. For students who have completed Course I or who have prior experience in educational computing.

Main Topics:
1. Theories of learning and other general psychology that pertains to learning from and using computers and related technology (e.g., human factors research).
2. Application of theory in various instructional computing modes (simulation, drill, tutorial, etc.), including evaluation of software and hardware configurations.
3. Computers and education of special student populations (gifted, handicapped).
4. Implementation problems and strategies (facilities, staff development, programming languages).

Course III. Computer Courseware Development

Goals: Develop student abilities in the design, construction, and refinement of instructional sequences using microelectronic technology.

Main Topics:
1. Review of courseware strategies and their strengths and weaknesses.
2. Analysis of instructional design considerations (learner characteristics

and technology interfaces, sequence and learner/program control, evaluation and feedback, graphics and text presentation style).
3. Analysis and use of courseware programming languages (e.g., BASIC, Pascal, PILOT).
4. Advanced programming techniques (modular/blocked/structured design, specialized subroutines for response logging, reinforcement, formatting, or error trapping, graphics and animation, sound and color).
5. Student courseware projects.

Course IV. Research Seminar in Instructional Computing

Goals: For students who want to conduct or apply current research on educational uses of computers, a survey and critical analysis of the research literature. (This course has not yet been offered.)

Of these core courses, the first has been offered most often (several sections each semester and summer for over a year) and is most clearly defined. The second and third are evolving through practice, with different contributions from the various faculty who are involved. To help guide this development and to stimulate further faculty and program development in the College of Education, a member of the Computer Science faculty will spend the academic year 1982-83 on leave in the College.

Because computer education course offerings are of such recent evolution, the program requirements for undergraduate and graduate students in the College do not yet include this topic. However, the new program proposed for early-childhood-elementary education includes the first computer course as a requirement. Many graduate students, from departments throughout the College are electing one or more of the courses.

Right now there are plans to design a course in the teaching of computer science in secondary schools - parallel to similar courses for teaching of English, science, and mathematics. Such a course, examining curriculum an instruction methods for high school computer science teachers, could meet a clear need in helping schools add this content area to their programs. Right now, college staff limitations and lack of any clarity about the proper focus for pre-college computer science curricula (perhaps to be somewhat settled by the forthcoming AP syllabus) have stalled implementation of this course and its logical successor, an undergraduate degree in computer science education.

Computing Facilities - One of the key factors that has contributed to College involvement in instructional computing is the ease of access and control provided by micro-computers. After several faculty purchased personal computers and used them in class, the Educational Technology Center provided leadership and support for a College micro-computer lab. An ad hoc College micro-computer advisory committee, chaired by the Ed-Tech Center coordinator, analyzed college needs and made three basic recommendations on facilities:

1. College micro-computer equipment should be centered in a single Ed-Tech Center location, accessible to everyone in the College.
2. For classroom instruction, a classroom with 12 micro-computer stations should be provided, adjoining an individual learning laboratory with 15 stations. Considerations of security, furniture, air conditioning, power outlets, etc. are listed too.
3. Estimated equipment projection to 1984-85 includes: 32 micro-computers, 40 disc drives, 16 color and 16 black/white monitors, 1 color TV projector, 8 printers of varying quality levels, 6 modems, 5 carrying cases, and further peripheral devices averaging $200 per computer.

The estimated total cost is $100,000 and as of June, 1982 roughly half of each request is in place with a firm College commitment to the balance. In order to maximize software compatibility, a single brand is to be the primary equipment. Purchase of single units of the other brands used in educational settings is planned - to make the variety available for faculty study and classroom demonstration.

In addition to basic hardware facilities, the College committee recommended expansion of the modest Ed-Tech Center software library. Key departmental users of the facility (especially Curriculum and Instruction) are to support the bulk of this acquisition cost. The College Curriculum Laboratory has been asked to expand its collection of computer-related print material.

Research - The educational potential of computers has stimulated several kinds of research in the Maryland College of Education. First, the Center for Young Children has parlayed a grant of equipment into clinical studies of the ways that micro-computer-based activities might enhance early concept learning by pre-school children. Second, an educational psychologist, using animated computer graphic displays, is studying the effects of

arcade-type games on spatial perception abilities of young people. Early results suggest remarkable impact. Third, faculty in measurement and statistics have begun research on the feasibility of micro-computer-based assessments of student learning.

Fourth, a project joining education, mathematics, and computer science faculty is exploring curricular changes in traditional secondary and college programs that are made possible or imperative by the power of computers as problem solving tools. The largest of the four research efforts addresses three central questions: (1) Which of the skills currently taught in school mathematics will soon be readily accessible on computing equipment that is widely available? (2) What levels of understanding and technical skill do computer users need in order to enlist machine power as an effective aid in problem solving? (3) What curricular changes are implied by answers to (1) and (2), and what change strategies are likely to be effective? The teaching experiments and content analyses of this project are exerting significant influence on the focus of mathematics education graduate programs. During 1981-82 the faculty/graduate student seminar had eight guest speakers and discussions on computer induced changes ahead for school mathematics. The mathematics methods and curriculum (graduate) courses now regularly include demonstrations of computer applications in teaching and extended analysis of the curricular implications.

Prospects - In 1981 a full report of computer education activity at the University of Maryland College of education would have been very short. But in the past eighteen months the number of knowledgeable and interested faculty has grown rapidly. Instructional offerings and research projects in computer education have expanded to meet apparently strong demand and pressing unsolved problems. Facilities are being provided rapidly. The mood is upbeat, but beneath the obvious enthusiasm and optimism there are some fundamental problems.

First, most of the current instructional and research effort on computer education is being carried by faculty with formal training and primary interest in other academic content areas. The course offerings reflect their sometimes narrow, self-taught skills and interests. The courses that have been developed may be appropriate for the intended audience. But computing is expanding and changing so rapidly that it is very difficult for someone less than a specialist in computer education to keep abreast of the field and to continually translate the best ideas into state-of-the-art courses. We need such faculty and they are not easy to find.

At the present time, we offer neither undergraduate nor graduate degrees in computer education. From the perspective of a College of Education, it is not easy to determine the proper computer science content in preparation of computer educators. It seems clear that knowledge about human learning and instructional design will be useful. For those who will become curriculum developers, a broad perspective on curriculum structure and change strategies will be essential. For those who will teach computer science topics like programming, it would be helpful to provide ideas that represent the best of experiences that have been accumulating over the past several decades. But the background knowledge and skills in programming, computer structure, data structures, and so on that are appropriate should be given careful attention.

AN UNDERGRADUATE MINOR AND GRADUATE PROGRAM IN COMPUTERS IN EDUCATION

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Lesley College is one of the largest, private teacher education institutions in the country. Over the last three years we have initiated undergraduate and graduate programs in the use of computers in education. The goal of both programs is to educate our student in the educational uses of this technology. Our graduate students, predominantly women, have majored primarily in a social science or languages as undergraduates. Our undergraduates, all women, are historically weak in the sciences and mathematics. Both groups of students would find it difficult to acquire a basic knowledge of computers through a traditional computer science approach. Consequently our program is designed for an audience lacking a strong mathematics or science background. We currently have about 40 undergraduates enrolled in the computer science minor (out of a 600 student population) and about 50 part-time graduate students (out of a part-time population of about 2,000 students).

The seeds of our computer programs go back to 1978. Two faculty members, who shared an interest and enthusiasm for educational computing, wrote a proposal to Digital Equipment Corporation for a computer. The request was granted and a PDP11 V03 arrived within a few months. The two faculty members had some experience with computers. One had worked with the MIT Logo Group, the other had worked in the area of simulation with the MIT System Dynamics Group. Neither, however, were computer scientists. Both began as elementary school teachers and are now teacher educators.

The first steps taken in designing a computer program involved meeting with a variety of people involved with computers in the Greater Boston area. This resulted in a network of people with interests in computer education who have worked together since then. The major project of this group, now called the Computer Education Resource Coalition (CERC), is to run an annual computers in education conference. A second group goal, perhaps even more important, is self-education. Through informal seminars, the group learns from each other and works together to fill common knowledge gaps.

This group has also been the source of most of Lesley's faculty. The third full-time Lesley faculty person was recruited through CERC. He is currently in a doctoral program at MIT and also has been an elementary school teacher.

The Lesley College Computer Center thus began with a DEC machine with four terminals and very little software. The computer program began with one introductory course. Today we have an undergraduate minor in computer science and a full graduate program. The Computer Center consists of two rooms of microcomputers. One room is a classroom with ten micros (Apples with 64K, two disk drives), color monitors, two printers, a variety of peripherals, and a large color monitor that can be viewed by the whole class. The second room is an open laboratory housing eleven microcomputers and two printers. Both rooms are located off the main library and are open during the same hours as the library (about 90 hours per week). There are student assistants or faculty members available to provide assistance about 30 hours per week.

The computer equipment has been purchased piecemeal, over the last three years except for eight of the micros which are on long-term loan from a computer manufacturer. Much of the software collection had been donated. Lesley College was a test site for the development of the micro versions of both Logo and DYNAMO. Moreover, as a result of the CERC network, we work closely with most of the educational software companies in the area. This often results in software donations. Our collection is now on closed reserve. Our current plan is to duplicate the collection through additional donations or purchases so one copy of everything can circulate.

THE UNDERGRADUATE PROGRAM

The undergraduate program includes both an introductory computer course required of all students and a minor in computer science. The required course was instituted two years ago during a major institutional curriculum revision. It is taken by all students during their freshman year. This course provides the "groundwork" for exciting potential extensions of the uses of computers in a variety of other courses in the college curriculum. Already students are receiving additional exposure to the use of computers in some of their education classes. A pilot project involving use of word processing as part of the instructional process in English Composition has been planned.

The minor in computer science was introduced in the spring of 1981. All students must take a liberal arts minor which varies from 14-21 semester course credit hours (a credit hour equals fifteen class hours). They may choose from several options of which the computer science minor is now one. Already several students have declared an interest in this minor. Each course is three semester credits.

The minor in computer science is designed to provide students with an understanding of computers and an opportunity to use computing. Laboratory experiences involve the use of microcomputers. A total of 14 credits are required from the following course selection.

PROGRAMMING IN BASIC emphasizes the methodology of program design. Experience in programming solutions to a variety of problems using the BASIC language is provided. Some attention is given to the study of computers as a scientific discipline.

PROGRAMMING IN LOGO provides an intensive exposure to the uses of the Logo language and includes activities involving graphics, music, robot control, and interactive games. An introduction to the educational philosophy behind Logo is included.

COMPUTER STRUCTURE: FUNDAMENTALS OF ORGANIZATION AND OPERATION provides an introduction to computer hardware, its organization and its operation. The course includes some exposure to programming in machine or assembly level language.

INFORMATION SYSTEMS FOR COMPUTERS considers techniques for organizing and operating on large quantities of information. Implications of the use of computerized data bases are investigated. Programming assignments require a knowledge of BASIC.

PROGRAMMING IN PASCAL focuses on programming using the Pascal computer language. Equal emphasis is placed on learning Pascal and on developing good programming style. Some attention is given to the analysis of programming language structures in general.

THE GRADUATE PROGRAM

The graduate program, offering both a master's degree and a certificate of advanced graduate study (CAGS) is composed of thirteen different computer courses plus an optional Field Study. Student programs are individually designed depending on the backgrounds and perceived needs of the students. The first nine courses described below are generally taken by all students. Following each course description are some comments on what has been learned over the past few years. All course are held at the Lesley College Computer Center. Generally half of each class period, which is three hours long, is devoted to a hands-on computer experience under the supervision of the professor.

The First Level Course

COMPUTER LITERACY/INTRODUCTION TO BASIC, DYNAMO AND LOGO is the first, introductory course. The course supposes no computer experience and is the prerequisite for all the other courses. The course begins with a brief introduction to the history, architecture and logic of computers. Students are then exposed to three different computer languages: BASIC as a general purpose computer language widely available in education settings; DYNMO as a simulation language; and Logo as a language developed for use with children. In addition, there is an introduction to word processing and some experiences with information retrieval and data processing.

Our experience suggests that it often takes the full term (15 three-hour sessions) to bring most students to a reasonable comfort level of interaction with a computer. Some students conclude that they do not want to become programmers by the end of this course, but almost all become very enthused about the unlimited possibilities of computers as educational tools.

Second Level Courses

COMPUTERS IN THE SCHOOLS: APPLIED USES FOR TEACHERS, ADMINISTRATORS AND SPECIALISTS is a course whose content focuses on the multiple uses of the computer as an administrative tool in education in general and classrooms in particular. Emphasis is on the development of planning skills necessary to the success of implementing computers in education. Students have hands-on experiences both with a variety of computer based administrative techniques, as well as educational computer data bases.

PROGRAMMING IN BASIC: A STRUCTURED APPROACH provides an introduction to the BASIC language and to structured problem solving. Structured programming through the use of Pseudocode is taught as a technique for thinking about program development and a general purpose programming tool. The course and the projects focus on educational applications. This course was specifically designed as a structured programming course because of the difficulties the first group of students had with Pascal. This course is thus a prerequisite for the Pascal course.

PROGRAMMING IN LOGO involves hands-on experience in programming in the Logo computer language, a language developed as a vehicle for children, enabling them to learn about computer programming, problem-solving, and other areas of "formal" knowledge. Logo transforms the computer into a tool for children, as well as adults, to explore a wide variety of knowledge worlds, ruled and manipulated by mathematics. Participants learn the Logo language and some of its applications in areas such as geometry, physics and music. The course includes an intruduction to the educational philosophy behind Logo.

INTRODUCTION TO THE PASCAL EDITOR teaches the Apple Pascal Editor in preparation for the Pascal and Simulation courses. In addition, this one credit course presents the many software packages now using this language.

Third Level Courses

INTRODUCTION TO COMPUTER SIMULATION exposes students to the use of the computer as a laboratory tool to aid in understanding complex situations. It involves formulating and experimenting with computer models -- computer programs designed to imitate the structure and behavior of real situations. The focus of the course is on defining problems for model building, conceptualizing system structure, writing model equations, simulation experiments, issues in model validation, and policy analysis with a simulation model. Simulations are performed in the DYNAMO computer language.

PROGRAMMING IN PASCAL: INTERMEDIATE PROGRAMMING TECHNIQUES presents modern techniques for designing and writing software on microcomputers and focuses on the use of the computer language Pascal. The course includes top down design, structured programming, Pascal control structures, data structures, documentation and graphics. The course is oriented toward educators who wish to develop educational software usable at elementary and secondary levels.

EVALUATION AND DEVELOPMENT OF EDUCATIONAL SOFTWARE begins with a detailed review of a variety of uses of computers in education such as simulations, instructional management, drill and practice, games, and problem solving. Current evaluative criteria for educational software are explored followed by the development of criteria for the next generation of educational programs. Part of each session is devoted to an aspect of the development process of educational software such as effective use of the computer's capabilities, standards for documentation, appropriate pedagogical strategies, programming aids, and evaluation. During the laboratory time students work on developing their own educational programs.

Fourth Level Couses

FUNDAMENTALS OF COMPUTER STRUCTURE provides background on microcomputer hardware and practices to train educators as resource persons in their schools. Instruction focuses on:

- binary arithmetic and digital logic as the fundamental language of computers;
- computer architecture and operation;
- assembly language programming;
- hardware and software interfacing techniques;
- a survey of equipment, techniques, and terminology in a variety of microcomputer systems.

Digital logic chips are used to construct simple counters and display circuits. These circuits become building blocks toward the final project of a serial data interface. The Apple II microcomputer is used to study operation and machine language programming. Programs are developed to provide the software for the serial interface project. The course concludes with comparisons of various microprocessor-based systems, including the

8080, Z80, and newer 16-bit architectures.

Electives

Second Level Electives

INTEGRATING MICROCOMPUTERS INTO THE MATHEMATICS CURRICULUM discusses the issues involved in the use of microcomputers in mathematics classes. The course focuses on program writing, use and evaluation of commercial software, and strategies for introducing computers into the math curriculum.

Third Level Electives

INFORMATION SYSTEMS FOR COMPUTERS focuses on techniques for representing and manipulating data structures. The use of sequential and random access files is explored. Structured programming techniques are employed in developing solutions to a variety of problems.

COMPUTERS AND THE SPECIAL NEEDS CHILD focuses on computers, the Logo language and the unique impact of these on a wide spectrum of students. Curriculum materials are demonstrated showing the use of the Logo System in areas such as computer programming, mathematics, and language arts. The first part of the course introduces students to the educational philosophy that has developed over the past 14 years at the MIT Logo Laboratory. The second half focuses on current research projects involving the use of Logo with special needs students. Associates of the MIT Logo Laboratory present guest sessions on their specialties throughout the course.

LOGO II involves the study of advanced Logo programming ideas. Recursion and a recursive approach to problem solving, creating procedures that output, non-graphic uses of Logo, file management and manipulation, "bullet-proofing" programs, direct access to the Apple's memory, debugging, and Logo data processing techniques are included. The course also discusses participants experiences using Logo with children, taking a deeper look at Papert's vision of learning.

Fourth Level Elective

FIELD STUDY, the last course for which students register, is a 180 hour internship in an on-site placement either similar to one to which the student will be returning or something very different from anything they have yet experienced. Some of the internships in which students have worked include: an educational publishing house working on a book series about using computers in education; a K-12 public school system's computer resource center; with a new, educationally oriented software company; a non-profit educational center focusing on products and services related to computers in education; with a junior high school teacher responsible for integrating computers into her school; and in a rapidly growing computer manufacturing company training their own personnel in using computers. Because of our geographic location in the "high tech belt", there are endless numbers of opportunities for internships.

Both our undergraduate and graduate programs are relatively new. In addition, we have just launched a National Outreach Program. We are bringing our complete graduate programs to off-campus locations. Our first two sites are Denver, Colorado and Concord, New Hampshire. We will soon begin a program in Pheonix, Arizona. We are constrained by the availability of faculty. To cope with this problem we have begun training our own graduates. We identify promising students to serve as teaching assistants in courses at Lesley. Then, once they have graduated, we have them work off-campus as teaching assistants with a Lesley faculty member. We are beginning to give them primary responsibility for courses both on- and off-campus. We have found we are more successful training our own students, or retraining our own faculty, than training people from other institutions. One reason for this is that our students generally have a precollege teaching background and therefore can relate well to other students with similar backgrounds.

We are also providing inservice computer education courses for Lesley faculty with backgrounds in the liberal arts and the human service areas. Our objective is to help them think about the impact of computers on their own discipline areas. We hope this introduction will begin to give them the skills they need to integrate computers into their own courses. However, some faculty might, in fact, choose to "switch" to the computer area, as the three current full-time faculty did several years ago.

We have encountered three general problem areas over the past few years:

1. Finding qualified computer faculty who can empathize with our students, their concerns and their backgrounds and knc ledge levels.

2. Finding teaching material with which our students can cope but will also give them the skills for leadership in educational computer applications.

3. Providing adequate student support in the open lab time.

We are attempting to solve these problems: The first by training primarily people with a precollege teaching background; the second by developing our own course materials; and the third, by continuously expanding the number of hours advanced studnets and faculty are available in the computer laboratory. In addition, we wrote the text, INTRODUCTION TO COMPJTER SIMULATION (Addison-Wesley, 1983) and were instrumental in the development of Micro-DYNAMO for our simulations course. We are currently doing the same for the hardware course. We hope to have a text, software, and a laboratory kit within the next two years. We are slowly accumulating material for the Logo course and look forward to finding the time to organize that into a text.

These are our most pressing needs. We are sure other needs will continue to surface. However, we are all finding this process of developing computer literacy in ourselves, our students and our colleagues to be professionally the most exciting challenge we have yet had.

IMPLEMENTING A PROGRAM TO TRAIN (RETRAIN) SECONDARY TEACHERS --- A COOPERATIVE EFFORT BETWEEN EDUCATION AND COMPUTER SCIENCE AT TOWSON STATE UNIVERSITY

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In Maryland, as in every other state in the union, the secondary schools are rapidly realizing the importance of computing in the curriculum. As is typical throughout the country, there are few secondary teachers with training or experience in computing. An effort to address this situation was the offering of a course, Computers and Secondary Education, at Towson State University (TSU) in the spring of 1980. While the course was enthusiastically received by the teachers, there was unanimous agreement that they needed more course work in Computer Science and a deeper understanding of some of the issues in Computer Science Education. In January 1981 a Faculty Development Grant was awarded to Professor Robert Wall, College of Education, and the author to plan a masters degree program to meet the needs of secondary teachers desiring to teach Computer Science. The resulting program proposal for a Masters Degree in Secondary Education with a Concentration in Computer Science was completed in the spring of 1981 and all approvals were completed by the spring of 1982.

The program is designed primarily for students who have a major or minor in mathematics or a minor in computer science and who have completed the courses in education that are required for state certification at the secondary level. Students without this background may find it necessary to take some undergraduate work to enter the program. Since few secondary teachers have had any coursework in computer science, the minimum requirements are differential and integral calculus, fluency in at least one programming language, a good grasp of the concepts of structured programming and an understanding of data structures. For a student with no exposure to computers or computing this could necessitate taking two three-credit courses in computer science, the first a lower division course in structured programming [probably Pascal] and the second course a beginning level upper division course in data structures and sorting techniques. [A suggestion has been made that a special three-credit graduate course be created to prepare students for this program. The rational for a special course is that mature students would be willing to put more work into a graduate level course, and many school districts would count such a course twoards hours beyond a bachelors degree and/or pay for the tuition.]

The program consists of 18 semester hours of education and psychology and 19 semester hours of computer science and mathematics. The work in computer science is designed to require 6 semester hours of coursework in computer science education and the remainder, 13 semester hours, in the subject matter of computer science.

To implement this program four courses in computer science at the graduate level, an independent studies course, and a special topics course were developed and approved. The special topics course will be offered as student demand, appropriate topic areas and faculty availability warrant such offerings. The independent studies course will allow for the design of an occasional special course for a student who may need or wish to study in a special area that is not covered by the current limited course offerings. For the present time students will be allowed to take a few 400 level computer science courses as subject matter electives. A few selected graduate courses in mathematics are also acceptable. Details of the program and a discussion of an acceptable program of study are discussed in section III.

I. Why is this degree program needed?

Few of the teachers now teaching in our secondary schools have had any training in the area of computing. Even the most recent graduates of pre-service programs are seldom required to take even one course in computing. In Maryland teachers are not required to

have any training in computing in order to be cerified to teach at the secondary level.

However, at Towson State University all sudents earning their bachelors degree with a Mathematics Major, Secondary Education have been required since 1974-75 to take at least one course in computer programming. Prior to that time these pre-service mathematics teachers were encouraged to take a course in computing and were allowed to count it as an elective in mathematics. [Students preparing to teach in areas other than mathematics are not required to take a course in computer programming. However, many of these students are now taking a computer programming course to meet their general university requirements of three courses in science or mathematics.] Unfortunately, the few secondary school teachers with training and/or experience in computing are finding the offers of relatively high salaries in industry so appealing that significant numbers of teachers are leaving the teaching profession for more lucrative jobs. All this occurs at a time when parents and school personnel are realizing the necessity of computers in the classroom.

Secondary schools are facing the same problems that were faced by the institutions of higher learning many years ago. There are not enough qualified faculty, not enough computers, and not enough teaching materials to do the job that needs to be done. However, the task of the secondary schools is orders of magnitude greater, for the population of the secondary schools is so much larger than the relatively small number of students in the specialized fields that the institutions of higher learning were confronted with educating some years ago. This is exacerbated by the national shortfall of people trained in computing. Today institutions of higher learning remain very shorthanded in qualified faculty, but most have seen vast improvements in textual materials and some improvement in both quantity and quality of computer equipment.

It is believed that a program leading to a Masters Degree in Secondary Education with a Concentration in Computer Science will appeal to dedicated teachers who are committed to remaining in teaching. There is no doubt that some of the graduates of the program will not go into teaching. However, appropriate programs for training teachers to use computers effectively in the classroom are essential in todays society. With the low turn-over rate in the teaching field, it seems that training or retraining for current teachers is needed. Simultaneously efforts need to be undertaken to insure that all the students in pre-service training are receiving appropriate training in computing. Efforts to address the needs of elementary teachers are currently being studied.

II. Why at Towson State University?

Towson State University began as a normal school, became a teachers college, later a college, and more recently a university. Throughout its history it has been known for the quality of the teachers trained at this institution. The changes in the population in the last decade have had a great impact on TSU. The decline in the school age population and the zero or negitive growth in teaching positions has meant that the College of Education has had far fewer students than were enrolled in the early-to mid seventies. This has occurred while the university has experienced overall growth. Some faculty members from the College of Education have developed competency in other areas of teaching, but there is still concern with the low enrollments in this college. This new program should contribute to increased enrollment in the College of Education.

It is felt that this program will be mutually beneficial to all parties: the university, the secondary schools, and to the students and faculties of both.

Cooperation between the College of Education and the science and mathematics departments in training teachers has been a long tradition at Towson State University. Students take the required education courses in the College of Education and the subject matter, methods and supervised teaching in the appropriate science or mathematics department. This same arrangement is foliowed in the Master of Secondary Education programs. Half of the course work is taken in the College of Education and the remainder of the coursework in the Department of Mathematics and Computer Science.

III. The program for a Masters Degree in Secondary Education with a Concentration in Computer Science.

The Master of Education degree program in Secondary Education is designed to help teachers develop competencies that will contribute to success in the general areas of education, psychology, and a teaching field. The Concentration in Computer Science affords the teacher the opportunity to review innovative new methods of teaching computing as well as to increase his/her technical knowledge in breadth and depth. The program has been designed to allow maximum exposure to Master's level computing courses

which are relevant to the classroom situation. There is considerable emphasis on applications and computing in an historical perspective.

The program:

1. Course requirements for the degree (Concentration in Computer Science, without thesis, minimum 37 semester hours. At least 28 hours of the program must be taken at the 500-600 level.)
   Required courses:
   a. Education (12 hours)
      Educational Ideas in Historical Perspective (3) 0801.501
      Introduction to Research in Education (3) 0801.691
      Seminar in Secondary Education (3) 0803.681
      Curriculum Development in the Secondary School (3) 0803.641
   b. Psychology (3 hours)
      Developmental Psychology (3) 2001.511
   c. Electives in Education (3 hours)
   d. Mathematics and Computer Science (19 hours)
      Individual programs should be selected in consultation with the Mathematics and Computer Science Department Graduate Committee. All programs are subject to the following requirements:
      i. Statistics [elementary statistics and computing] (4) 1701.530
      ii. Computers in Secondary Education (3) 0701.507
      iii. Seminar in Computer Science Education (3) 0701.525
      iv. Electives in Computer Science (9 hours)* from among
         Database Management Systems (3) 0701.457
         Artificial Intelligence (3) 0701.461
         Computer Graphics (3) 0701.471
         Computer Simulation (3) 0701.511
         Hardware and Software in Microcomputers (3) 0701.513
         Special Topics in Computer Science (3) 0701.570-579
         Independent Study in Computer Science (3) 0701.590

      *one of the following courses may be taken in lieu of Computer Science course (section iv.)
         History of Mathematics (3) 1701.501
         Seminar in Mathematical Applications (3) 1701.591

Admission to the Graduate Division at Towson State University is determined without regard to race, color, religion or sex. All students seeking admission must file and "Application for Admission to Graduate Studies" prior to first enrollment and have official transcripts of all college work sent to the Graduate Division. Additionally, the requirements for admission to the M. Ed. program in Secondary Education - Concentration in Computer Science are:

1. Undergraduate requirements in Education:
   a. Certification as a secondary public school teacher
   OR
   b. Courses in the following areas:
      (1) Educational Psychology or Human Growth and Development
      (2) Principles and Methods in Secondary Education
      (3) Three hours choosen from the following areas
         i. History of Education
         ii. Foundations of Education
         iii. Philosophy of Education

AND

2. A Bachelor's Degree with a major or minor in Mathematics or Computer Science or the equivalent conferred by an accredited college or university. This should include at least one year of college level calculus (1701.273-274) and a course in data structures (0701.336).

Other requirements for the M. Ed. are the filing of a Program of Study with the Dean of Graduate Studies, Advancement to Degree Candidacy, and the filing of a Diploma Card in the Graduate Division.

Advancement to Candidacy in the M. Ed. program in Secondary Education is attained as follows:

1. Application (made no later than the semester following the one in which fifteen credits are completed and no earlier than a semester by which nine hours of graduate courses have beeen completed).
2. Six credits in 500 or 600 level courses.
3. A 3.00 ("B") average in all graduate work at this university.

4. Completion of 0801.501 "Educational Ideas in Historical Perspective" with a grade of "B" or higher.
5. The filing of a Program of Study (to be planned with and approved by the Graduate Advisor within the semester the student is granted Graduate Studies.
6. The completion of all undergraduate requirements.

Transfer credits can be arranged. [Complete details are available in the T.S.U. Graduate Bulletin.]

A SAMPLE COURSE OF STUDY FOR A STUDENT ENTERING WITH MINIMUM BACKGROUND*

Required courses (25 hours)

Educational Ideas in Historical Perspective 0801.501	(3)
Introduction to Research in Education 0801.691	(3)
Seminar in Secondary Education 0803.681	(3)
Curriculum Development in Secondary School 0803.641	(3)
Developmental Psychology 2001.511	(3)
Statistics 1701.530 (4)	
Computers in Secondary Education 0701.507	(3)
Seminar in Computer Science Education 0701.525	(3)

Elective courses (12 hours)

Education	(3)
Computer Science:	
Computer Simulation 0701.511	(3)
Hardware and Software in Microcomputers 0701.513	(3)
Database Management Systems 0701.457	(3)

*Students with no background in computer science could begin this program and take the education courses and the course in statistics (1701.530) to familiarize them with one programing language. They would then have to take two undergraduate courses to prepare themselves for the remaining computer science courses. These undergraduate courses would be Structured Programming (0701.236) and Data Structures and Sorting Techniques (0701.336).

COURSE DESCRIPTIONS AND OUTLINES FOR GRADUATE COURSES

Computers and Secondary Education: This course is designed for teachers in secondary schools to acquaint them with the uses of computers at the secondary level and to present methods and materials for use of the computer in the classroom. Prerequisites: knowledge of at least one high level programming language and teaching experience or completion of student teaching or consent of the instructor.

Outline:

1. Overview of computers and education
2. Teaching about computers
   a. computer literacy
   b. goals of teaching programming
   c. structured programming
   d. computer science in secondary schools
3. Computers as aids to learning
   a. packaged programs
   b. information retrieval
   c. simulation
   d. student-written programs for problem solving
4. Computer-aided instruction
   a. overview
   b. current literature
   c. some applications
5. Computer-managed instruction
   a. overview
   b. some applications
   c. current literature
6. Computing facilities
   a. overview
   b. some software and hardware considerations
   c. terminal facilities
   d. components of a quality computing service

e. operating a small computing facility
7. Sources of additional information
   a. books
   b. periodicals
   c. films
   d. guest speakers
   e. tours
   f. computer-education projects

Computer Simulation: This course will introduce the process of modeling and simulation with emphasis on applications. Simulations will be examined for which modeling and simulations techniques are appropriate. Formulation, implementation and manipulation of models will form a significant portion of the course. Prerequisites: 1701.530 (Statistics), 0701.336 (Data Structures and Sorting Techniques).

Outline:
1. Abstractions and models and axioms
2. Random number theory and generators
3. Monte Carlo method
4. Queues
5. Stochastic process (Markov chains)
6. Gaming
7. Simulation languages (e.g. GPSS, SIMULA)
8. Simulation packages
9. Validation of simulation models.

Hardware and Software in Microcomputers: This course is a survey of microcomputers, hardware and software. Topics covered will include basic hardware and enhancements; software availability and implications; utilization of microcomputers; selection criteria and installation management. Prerequisite: 0701.336 (Data Structures and Sorting Techniques).

Outline:
1. Software
   a. availability (sources)
   b. transportability
   c. implications of copyright laws
   d. languages
   e. packages
2. Hardware
   a. general organization
   b. I/O devices
   c. interfacing
   d. networking
3. Utilization
   a. in stand alone mode
      1) graphics
      2) work processing
      3) programming
      4) other uses
   b. when using amodem
      1) program sharing
      2) data sharing
      3) data resource
      4) electronic mail
      5) other
4. Selection criteria
   a. cost
   b. service
   c. power
   d. languages
   e. packages
   f. special options
   g. upgrading
   h. expandability
   i. security
   j. other

Seminar in Computer Science Education: This course is designed to provide students with an opportunity to analyze research trends and critical issues in computer science education. Prerequisite: Computers in Secondary Education. 0701.507

Outline:
The students are expected to have an appropriate background to study, in depth, the field of computer science education.

1. study and discuss topics, materials and programs in computer science education.
2. students will choose, or be assigned, topics to research. The results of the the research will be presented to the class as a whole.
3. the instructor will aid the students in choosing topics, give guidance to resource materials, and evaluate papers, projects and presentations.

COMPUTERIZING THE TEACHER AT NORTH TEXAS STATE UNIVERSITY

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Introduction

Computer education has been an area of concern and effort at North Texas State University for several years. Support for the programs of study is based upon the cooperative efforts of the Department of Computer Sciences and the College of Education. The independent strengths of these two academic areas, coupled with a joint concern for the training of teachers and administrators in computing, has provided an atmosphere for comprehensive programs of study in computing for educators at all program levels.

North Texas State University is a university with over 17,000 students offering undergraduate and graduate programs through the doctoral level. The Computer Sciences Department is one of the largest in the country with over 800 undergraduate and 150 graduate student majors and is administered through the College of Arts and Sciences. The College of Education services over 1200 undergraduate and 1500 graduate student majors, and is currently the largest teacher-training school in Texas in terms of combined semester credit hours at the undergraduate, masters and doctoral levels. In addition, the College ranks among the top ten in the nation in the number of education majors enrolled in doctoral study.

Programs of study in computer education include specialized courses for undergraduate and graduates, teacher certification programs in computer science, and an interdisciplinary masters degree in Computer-Based Educational Systems. Two doctoral programs, one in Educational Research and one in College Teaching, both allowing concentration in computer science, are also offered. The following sections elaborate on these programs of study.

Specialized Computer Education Courses

Five specialized courses, two within the College of Education and three within the Department of Computer Sciences, provide students with a choice of computer related courses designed specifically for educators. The use of these courses range from preservice training of teachers to satisfaction of the language tool requirement for doctoral candidates.

Introduction to Instructional Technology. EDUC 344. This course, offered by the College of Education, is an undergraduate course that concentrates on instructional media. As instructional media has evolved in education, this course has been modified to include a significant component in computing. The thrust of the computing component, approximately 25% of the total course, is to enable teachers to effectively use computers for instruction and management in the classroom.

Computer Science for the Teacher. CSCI 410. This course is a senior level course offered within the Computer Sciences Department. It is a requirement within the teacher certification program in computer science and provides instruction in educational programming and instruction on the utilization of educational application packages. Motivation for and objectives to be reached when teaching computing at the precollege level represent major components of this course.

Computers in Education. CSCI 510. As a graduate level computer science course, this is a popular course taken by teachers returning for summer coursework. It is offered as a service course by the Computer Sciences Department and covers topics such as educational applications, computer assisted instruction, evaluation of computer-based courseware and BASIC programming on microcomputers. It is a required course within the masters and doctoral level programs described in a later section. This course has been very popular when taught during the summer on an accelerated basis. Teachers from across Texas and various other states have enrolled for a two week session to concentrate their studies on computer education.

Computer Assisted Instruction. CSCI 511. This graduate level course, offered by the

Computer Sciences Department, is designed to provide experience in designing computer-based instructional materials. CAI authoring languages such as PILOT and Instructional Dialogue Facility (IDF) are studied and compared. Students utilize these packages to author their own CAI lessons. While the previous courses required no prior programming knowledge, this course requires programming expertise in at least one programming language such as BASIC or FORTRAN.

Educational Data Processing. EDER 624. This doctoral level course is offered by the College of Education and is designed primarily for school administrators. Data processing applications such as scheduling, registration and tax accounting are emphasized. The course has no prerequisite.

Teacher Certification in Computer Science

At the present time, very few states have guidelines and/or requirements for computer science teacher certification. However, as computing continues to grow as an instructional topic, the need for concentrated training of computing teachers will become more obvious. Certification programs will be encouraged and finally required by the state educational agencies. When the time comes, university level programs for such certification should be available now for the current preservice teachers.

Specific certification requirements for teachers vary from state to state. The state of Texas requirements include a sequence of coursework in professional education and "teaching fields" in at least two academic disciplines, one of which may be computer science. Each teaching field requires completion of at least 24 semester hours of coursework.

The 24 hours of coursework in computer science at NTSU is a combination of required and elective courses. Each student is required to complete the following twelve hours:

CSCI 110 - Introduction to Computer Science (with BASIC)
CSCI 111 - Program Development (PASCAL)
CSCI 310 - Systems Analysis
CSCI 410 - Computer Science for the Teacher
OR
CSCI 510 - Computers in Education

The remaining 12 semester hours may be chosen from any of the other computer science courses offered within the department. (An appendix gives the course descriptions of the computer science courses listed as requirements.)

Master of Science in Interdisciplinary Studies: Computer-Based Educational Systems

The Interdisciplinary Masters Degree in Computer-Based Educational Systems is a cooperative program between the College of Education and the Department of Computer Sciences designed to meet the needs of educational personnel interested in computing. Prerequisites of the program include eighteen semester hours of behavioral sciences and six hours of computer sciences. This program is of particular interest to those teachers returning for a masters degree with little or no computer training but with a desire to become an educational computer professional. Moreover, by choosing prerequisite and elective courses carefully, one may also satisfy certification requirements in computer science without additional coursework.

The masters program includes 38 graduate semester hours. Eighteen hours of education, seventeen hours of computer science and three elective hours are required. While some variation is possible, the following is a typical degree program:

Education:

EDUC 505 - Educational Research and Evaluation
EDUC 522 - The Evaluation of Educational Programs
EDUC 524 - Technological Media in Education
EDUC 544 - Media in Education
EDUC 551 - Message Design and Instructional Development
EDUC 620 - The Technological Age and Education

Computer Science:

CSCI 504 - Systems Analysis and Assembly Language Programming
CSCI 505 - Data Structures and Systems Programming
CSCI 510 - Computers in Education
CSCI 511 - Computer Assisted Instruction

CSCI 521 - Text Processing
CSCI 589 - Directed Studies

CSCI 504 and 505 are four hour credit courses that are primarily leveling work courses. They each cover the same content as six hours of undergraduate courses and include projects designed for graduate students.

A student's advisory committee is made up of faculty from Education and Computer Sciences. The Major Professor, the key advisor, may be chosen from either discipline and generally supervises the student's "Directed Studies" course.

Doctoral Programs in Educational Computing

There is an extreme shortage of qualified computer science faculty at all levels of education, particularly at junior colleges and universities, and it appears that this shortage will persist through the 1990's (SCIENCE, 1980). Moreover, throughout the educational field there is a meed for individuals qualified to carry on research activities in educational computing. NTSU has two doctoral programs in Education allowing a specialization in Computer Science. The Ph.D. in College Teaching and the Ph.D. in Educational Research are designed to provide programs of study encompassing both computer science and education. Graduates are prepared to carry on research activities in educational computing or to engage in college level instruction.

Both of the above degrees assume that a candidate has completed a masters degree (it need not be computer-oriented) and at least 12 hours of graduate level computer science coursework. A minimum of 60 hours past the masters is required, including 36 hours of education, 24 hours of graduate level computer science and 12 hours of dissertation. With the 12 hours of prerequisite computer science, a graduate will have completed a total of 36 hours of computer science. In each case, a dissertation in educational computing may be chosen.

Computing coursework is chosen to fulfill individual needs and interests. However, completion of Computers in Education and Computer Assisted Instruction is required. An advisory committee is made up of two faculty each from Education and Computer Science. The Major Professor is generally chosen from the College of Education. However, the student may choose a faculty member with the Computer Sciences Department to direct the dissertation research.

Inservice

In addition to offering computer related education courses on an accelerated basis to serve educators in the field, faculty within the Computer Sciences Department and the College of Education conduct inservice training workshops. One and two day sessions have been organized and documented so that content remains constant regardless of the faculty member presenting. Films, computer assisted instruction materials and printed handouts are utilized in both programs.

Content of these workshops is designed for the computing novice. Emphasis is placed on the educator becoming a knowledgeable computer user. The use of the computer as an instructional aid and as a problem solving tool is emphasized. Although the thrust is not to train computer programmers, programming in BASIC is introduced assuming that equipment is available.

Whenever feasible, inservice workshops are held on the NTSU campus. Extensive microcomputer laboratories are then utilized for hands-on computer usage. The Department of Computer Sciences has over 75 microcomputers available for student use. Five microcomputer brands - Apple, TI99/4, PET, TRS-80 and Atari - are included, thus providing opportunity for comparative usage. A resource room containing the major computer education journals is also available for reference.

Summary

The College of Education and the Department of Computer Sciences at North Texas State University have provided a complete offering of teacher training programs in computer science. Teacher certification, masters and doctorate degrees in computer education, as well as specialized computer education courses are available to preservice and inservice educators. Such extensive program offerings are available primarily because of the close working relationship that exists between the two academic disciplines. Only by working in a cooperative fashion and using each others strengths, can computer scientists and educators successfully attack the massive problem of computer education for educators.

APPENDIX

RELATED COMPUTER COURSEWORK

COMPUTER SCIENCE:

110. Introduction to Computer Science. A basic course covering logical operation and organization of a digital computer, development of basic algorithms, number systems, boolean algebra, flow charting techniques and programming in the BASIC computer language. Recommended as first course for computer science majors. Prerequisite: two years high schol algebra or geometry or three hours of mathematics.

111. Program Development. 3 hours. Problem solving techniques; algorithmic processes; top down design; structured programming in a high level language. Prerequisite: CSCI 110.

310. Computer Systems Analysis. 3 hours. Principles of computer systems analysis and design, system hardware and software characteristics. Comparison of existing computer facilities. Prerequisite or Corequisite: Computer Science 201.

410. Computer Science for the Teacher. 3 hours. An introduction to computers in education. A survey of computer topics covered in introductory and secondary school courses. Motivation and objectives in computer education; some programming in the BASIC computer language survey of instructional uses of the computer. Not to be counted toward Computer Science major (may be counted as elective) unless computer science is to be a teaching field.

504. Systems Analysis and Assembly Language Programming. 4 hours. Principles of computer systems analysis and design, system hardware and software characteristics. Data representation, programming in assembly language. Leveling course for computer science majors. Prerequisite: CSCI 503.

505. Data Structures and Systems Programming. 4 hours. Computer storage structures; storage allocation and management; data sorting and searching techniques; data structures in programming languages. Design of typical system programs such as assemblers; addressing techniques, core management; file system design and management. Leveling course for computer science majors. Prerequisite: Computer Science 504.

510. Computers in Education. 3 hours. Analysis of computer uses in education. Computer programming applications in education. Prerequisite: 3 hours of computer programming.

511. Computer-Assisted Instruction. 3 hours. Study and analysis of the use of the computer as an aid in instruction in an academic area. Usage of computer assisted instruction packages such as the Hewlett-Packard instructions dialogue facility. Prerequisite: 3 hours of computer programming.

521. Text Processing. Use of computers to read, write and analyze text, manipulate symbols. Advanced programming techniques appropriate to nonnumeric data handling. Use of languages similar to PL/I, SNOBOL, TRAC, CASH, LISP. Processing of noncomputer languages. Text and re[illegible]diting Bibliography maintenance. Pattern recognition a[illegible] generation. Sorting, strings, list linked files. Macro processors. Recursive processing. Prerequisite: six semester hours programming courses or CSCI 501 or 502 or departmental approval.

589. Directed Study. 1-3 hours. Study of topics in computer sciences by individuals or small groups. A student taking CSCI 489 or 589 may work with other students taking these courses in the same topic if the faculty supervisor agrees. Prerequisite: open to students with graduate standing who are capable of developing problems independently. Six semester hours of Computer Sciences with a grade of A or B. The student is to prepare a plan for study of a topic and a plan for evaluation of the study achievements. Prior approval is required for the plan by the Computer Sciences Department Chairman and by a graduate faculty member who agrees to supervise the work. Credit: one to four semester hours, may be repeated for credit.

EDUCATION:

344. Introduction to Instructional Technology. 3 hours. Examination of basic techniques of instructional development, methods of instruction, materials and equipment which can be combined for teaching and learning in elementary, secondary and adult education.

624. Educational Data Processing. 3 hours. Computing systems and their impact on the planning and implementation of educational research projects. Emphasis on statistical

packages, organization and collection of data, computing hardware and software, and various display techniques. Prerequisite: individual approval.

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COMPUTERS IN EDUCATION AT THE UNIVERSITY OF COLORADO-BOULDER

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The School of Education at the University of Colorado (CU) has been involved in preparing students in the area of education technology for many years. Recent advancements in computer technology have caused increased emphasis on computers, as past changes in video technology (TV and video recording) caused greater emphasis in those areas. Past efforts in educational technology involved both graduate and undergraduate students primarily with respect to traditional technologies such as video equipment, still and motion picture projection, reproducing machines and other such equipment. In the past all undergraduates received training in the operation and use of this equipment as part of their teacher education coursework. Graduate students not majoring in education media would take courses involving "education media" as electives. This paper traces the influence of recent developments in computer technology on students, faculty, staff and programs in the School of Education at CU, and outlines recent developments which will shape the future.

Involvement in instructional computing in the School of Education, until the summer of 1979, can best be described as typical of other large universities. Prior to 1979 most computing in education involved statistical work on a large mainframe computer or involved the requiring of computing background for those persons in a few select areas in education, typically prospective mathematics teachers or persons in academic programs emphasizing statistical analyses of data for research purposes. For graduate students this involved batch processing of programs for statistical analyses in the sequence of courses in research and statistics, taken by most all graduate students both at the master's and doctoral levels. In addition doctoral students typically used this system for data analysis for doctoral research. At the undergraduate level only students preparing to be secondary mathematics teachers would have computing background. These students were (and still are) required to complete at least one course in "computing," usually completed by taking the first course in Computing Science which includes programming in the Pascal language, using batch and interactive processing on a large mainframe system. Many such students complete several courses in computing. The number of persons completing the secondary mathematics teacher certification program has varied between five and ten per year, and has constituted about five percent of undergraduates in both elementary and secondary teacher education. About 60% of graduate students typically would make use of computers but this involvement was almost exclusively statistical analyses for class assignments and to a much lesser degree for research purposes. Less than 20% of faculty were involved with computers for anything except statistical analyses for research projects and the number utilizing the computer for statistical analyses was not much greater than 20%. The above figures are estimates, not precise calculations.

Attempting to incorporate a significant amount of computing in any coursework in the School of Education at this time required the use of batch processing on the mainframe system because of the limited availability of terminals. The only resident equipment within the School of Education was an ancient keypunch machine. The computing facility itself is approximately two miles distant.

The first attempt to break out of the mainframe "mindset" began with a request, in the Fall of 1971, for resident equipment for the School of Education. This followed by a few months the release by Hewlett-Packard of their first "desk-top computer." These were labeled "calculators," a label which alleviated the problem of satisfying all the special rules associated with purchasing "computers". The single machine requested was to cost nearly $11,000. This first request was almost completely disregarded, since few educators felt there were any educational applications of these machines outside the areas of mathematics, science or statistics. Since the only possibility of use of existing computing facilities was batch processing or timeshare terminals (two miles away from the School) on a large mainframe system and with little or no appropriate software available there was little involvement in true instructional computing. The submission of requests for computing equipment for the School of Education was a twice yearly exercise which coincided with the cycle used by the university for equipment requests. Each request was slightly different from the one previous, reflecting progressive changes in technology. The physical size of the machines decreased, the capabilities increased (to include higher order languages as well as greater memory) and costs dropped steadily. Each request was, for all practical purposes, disregarded.

This cycle continued until the fall of 1978 when an administrative change within the School coincided with the marketing of the first of the microcomputers. The first microcomputer for the School of Education was purchased in the summer of 1979. Some faculty feel that this machine was purchased mainly to see what would result as a consequence, with little expectation that it would have a significant impact. Since the receipt of this first microcomputer the School of Education at CU has seen considerable activity with respect to microcomputers and within the last year there are indicators of an acceleration of activity.

CURRENT SITUATION

In the three years since the first microcomputer arrived in the School of Education:

1. Twenty microcomputers (and six printers) are now housed in the School of Education. All of these machines are Apple II+ machines with language cards. The decision to make all initial purchases Apple machines was based on at least two informal criteria. First, the primary focus of a school of education is education. It was felt that at the present time Apple machines have the greatest availability of educational software, and are the most common in schools. Secondly Apple machines were felt to be the most flexible. Therefore initial purchases, at least up to a number which could support standard university course instruction should be Apples. Once the minimal number of machines is reached (a very elusive number) then some purchases of other brands would be considered depending on their intended use.

   The most recent fifteen (including two printers) are housed in a "Microcomputer Laboratory". These fifteen machines are used in regular instruction in courses in the School of Education, laboratory work associated with these classes, courses in continuing education and "open" laboratory time for any interested user. The micro lab is housed in a room which is about 15 m by 7 m. The room has a chalkboard on one end wall and is equipped with electrical outlets on the remaining three walls in sufficient numbers and capacity to accomodate up to twenty-five stations. The existing fifteen stations are situated so that when students are present they face the front of the room with the keyboards at their fingertips. There are two chairs at each station allowing up to thirty students for a scheduled class. This arrangement appears to be the the most beneficial for instruction given the equipment that is available. The lab is supervised by a student assistant during the open use hours. The specific schedule for use of the lab varies depending on the classes scheduled.

2. An NSF grant of $85,000 has been received to conduct a project titled "Personal Computers and Cross-Aged Istruction". This is a school-based experimental study utilizing nine complete microcomputer systems (Apple II+ with language cards), seven of which have become the property of the cooperating school district, St. Vrain Valley Schools, and the remaining two systems are part of the permanent facilities of the School of Education.

   There were four primary objectives of this project.

   A. Increase the level of basic mathematical skill of mathematically low-achieving sixth graders.

   B. Increase the number of students enrolling in high school mathematics and science courses.

   C. Evaulate the use of microcomputers as a unique instructional tool.

   D. Develop effective applications of microcomputers in education (in this case a motivation and tutoring tool).

   These objectives were achieved by training high school students on the use of microcomputers and teaching them about the difficulties that sixth graders encounter in mathematics. Each of these students then tutored a sixth grade student every other school day for one semester. The project staff monitored both groups of students to determine the achievement of the objectives of the project. The experimental phase of the project was completed in May 1982. The interim report of this project is available through the ERIC system and the final report will be available in the spring of 1983.

3. The Center for Management Information Technology in Education (MITIE) has been formed to provide services to school systems in the area of administrative uses of computers. Dr. James Rose is the director of this center. This center has provided on-site courses for school and school district administrators on the use of computers in education administration, consulting services to school districts, conducted studies of the computing needs of schools and school districts and provided other support for

schools and school districts ir the area of the administrative use of information technology.

4. Several graduate courses have been instituted:

   A. "Computers in Education" is a survey course about computers and their use in education. The content of this course includes the history, characteristics, capabilities and terminology of computers: past, present and future of educational computing, both administrative and instructional; an orientation to microcomputer hardware and software; and includes on-site visits and demonstrations of current educational uses of computers. This course is designed for graduate students in all fields of education, is offered at least once per academic year and attracts thirty students per offering from many fields within education as well as students from fields outside education. It is a popular course and provides the foundation for other courses in education computing as well as serving as a terminal course for those students wanting only an overview of the field. There are no prerequisites for this course.

   B. "Computer Assisted Instruction" covers in detail the theory, design, development, implementation and evaluation of computer assisted instruction materials. Work on both mainframe and microcomputers is done in this course. Typically this course attracts students with some background in computing, some exposure to programming and some backgound in instructional design. This course is offered once per academic year and is designed for persons desiring in-depth work in the development of computer based instructional materials. It is anticpated that there will be increasing demand for this course.

   C. "Microcomputers in the Classroom" is a hands-on course for educators (primarily teachers) wishing an overall orientation to microcomputers, their operation, software and rudimentary concepts of programming. This course is offered three to four times per year including summers and attracts thirty students per section. Students from all areas in education as well as other disciplines are attracted to this course and about one half of the students are not degree candidates. The overall reaction to this course has been highly positive and it will likely remain popular for some time.

   D. An undergraduate course somewhat parallel to the Microcomputers in the Classroom course described above has been scheduled for the fall semester 1982. This course will allow undergraduates to accumulate a greater amount of background on microcomputers than is included in the ten hours of instrucion all such students will receive.

   E. Other courses are planned for the future, some of which will be developed in the 1982-83 academic year. Areas to be covered in additional courses will be the more technical aspects of computers, authoring languages, programming and development.

5. The use of microcomputers is being incorporated into the graduate course in School Finance. Computers are used in this course to model financial decisions and provide a base for projections for enrollments and finances within school districts. This course is taken primarily by persons seeking a school administration degree or certification and attracts about twenty-five students for each of one to two offerings per year.

6. Two sections of a semester long seminar on microcomputers for School of Education faculty and staff were conducted in the spring of 1982. This seminar dealt with the characteristics, capabilities, operation, machine commands, software and uses of microcomputers in instruction and research in education.

   The development and implementation of, and instruction in this seminar was the work of the writer of this paper. The seminar was not part of my regular assignment within the School of Education, but was done as a volunteer effort on my part and followed by four weeks the delivery of the first five of the microcomputers for the lab mentioned above. It was arranged because of my personal committment to the School and my sensing of the need and interest for such a program for the faculty and staff of the School of Education. It was also my attempt to be consistent with advice that I give to school personnel when I am asked what they should do first when getting microcomputers in their schools. My recommmendation under these circumstances is to spend a significant amount of time orienting their staff on the operation, use and potential of these machines, and to do this in a non-threatening supportive atmosphere. Only in this way will the staff support and encourage integration of micros into instruction.

   Recruiting for the seminar was accomplished merely by sending a memo to each of the

faculty and staff of the School, asking who would be interested in a weekly seminar on the use and operation of microcomputers. Before the memo was sent it was expected that up to ten persons would reply. Thirty-nine persons indicated their interest and two sections were arranged at times which allowed the greatest number of participants. Only one person could not attend one of the two sections. The level of interest can be ascribed to three things. First is the visibility that microcomputers had received in education in the recent past. Second was the general knowledge that the faculty had of my activities with respect to microcomputers over the previous two years, and third was the positive relationship I have with most all the faculty.

The seminar met once per week for a full semester each session lasting two hours (a total of thirty-two contact hours). The content of the seminar included an overview of features and capabilities of microcomputers , rudimentary concepts of machine control through machine commands and programming in BASIC; demonstrations of word processing/text editing (Sandy's Text Editor was used because of its simplicity but three other text editors are available), data management software (DB Master) and spread sheet software (VISICALC); a demonstration of LOGO (Krell Logo); and demonstrations of commercial instructional software including drill and practice, tutorials, simulations and games (SRA, Muse, Hayden, Sterling Swift, Educational Teaching Aids, EduWare, Developmental Learning Materials, and MECC among others). There were numerous handouts given in the seminar, all locally prepared and there were few demands made on the participants for outside work. Most all outside work was self-imposed by those participants who found the time (professors claim to be very busy), had sufficient interest and felt the need to have additional work on the machines. Five machines were available at almost anytime a participant desired to have machine time for "outside work."

The primary desired outcomes for the seminar were machine familiarization, getting the concept of machine control through machine commands and programming, overcoming machine anxiety, exposure to the more common types of software and to foster a positive attitude toward this new technology and its use in education.

Since the completion of the seminar several faculty have become involved with microcomputers who were not involved previously. The general reaction to the seminar was highly positive based on a written evaluation. No tests, quizes or term papers were required (you can't do that with the people you work with) partially because the participants and I were all colleagues and friends and partially to maintain a relaxed atmosphere. All feedback thus far has been positive and the apparent general feeling is that the individual objectives of the participants were achieved. Even the instructor is positive.

7. Several in-service courses for both teachers, administrators and others have taken place. In the past one and one-half years nearly ten courses relating to microcomputers have been conducted by faculty in the school or with the equipment in the school. These have been primarily orientation courses for school administrators and teachers. The content of these courses varies with the intended audience and with the specifics of the request for such a course, or; something similar to the content of the faculty seminar is common except the depth of coverage depends on the amount of time available. The course credit has varied from zero to three semester hours and the courses have taken place both in the School of Education and in schools around Colorado, with participants providing their own equipment when the course is off-campus. Requests for courses in this area typically address the need to upgrade the background of school personnel in an area where little background exists. It is anticipated that this need on the part of school pesonnel will be present for some time and more such sessions are expected. Coursework beyond first courses such as these are typically satisfied through regular course offerings or specially designed courses in response to specific requests. Such coursework may or may not fit into a degree program.

8. A School of Education committee for the coordination of efforts in education computing within the school has been formed. This committee is a Dean' committee and consists of the five persons most directly involved in using computer technology in the School of Education. The committee addresses questions relating to the priorities on the use of and acquisition of equipment, advises the dean on policy decisions related to computers in the School of Education, oversees possible duplication of effort among existing and proposed courses involving computing and coordinates efforts for the entire School on matters involving computers. The committee was established by the dean as an alternative to the more traditional approach to the appearance of a new area, which is to create a new program or division. It was felt that a committee would allow more flexibility at least in the intitial stages of activity, seemed to be the more appropriate arrangement in an area which is more interdiscipinary than existing areas in education and better accomodates the rapidly changing nature of the field.

THE FUTURE

Because of the rapid changes that are taking place in computing in general and in educational computing and due to the increasing demand for courses and programs in this area several activities and events will take place in the near future in the School of Education.

1. The faculties in elementary and secondary eduation both have approved the incorporation of a program for an orientation to microcomputers in education for all undergraduate teacher education students at the University. This program is to commence in the fall of 1982 and will include approximately ten hours of instruction. The specifics of the content and scheduling of this program are not yet firm, but will most likely include an overview of computers and their use in instruction, terminology, features of hardware, machine operation and demonstrations of instructional software.

2. Within existing graduate degrees emphases in several areas related to educational computing are being considered. One emphasis is for those persons wishing to concentrate on instructional systems and computers. Many of these persons will likely find employment in educational settings in industry. A second emphasis would be for persons planning to remain in school classrooms but wish concentrated work on instructional computing. A third emphasis would be for persons wishing to pursue supervisory positions in instructional computing in school systems. Each of these emphases has somewhat unique needs for graduate work. Each of these emphases could make use of coursework in computer science in addition to the coursework in education. Coursework in computer science is available since there are existing graduate degrees in computer science on campus and two new undergraduate programs in computing are being implemented on campus, one in computer science-engineering and another in the College of Arts and Sciences. The possibility of interested persons choosing one of these new emphases and the the availability of supporting coursework in computer science will provide competent persons for positions in schools, school systems and industrial training.

3. The dean's committee will be addressing several questions of logistics and questions of future equipment needs and priorities. Logistical questions include the scheduling of laboratory time, instructional time and resulting machine use; financing expendable materials associated with the laboratory; the availability of materials (books, diskettes and software) and how to address increased faculty use in light of increased use in instruction and by others. An important question that must be addressed concerns future purchases of equipment and what kind of equipment should be purchased. Up to now all purchases were Apple machines, for the reasons cited above. It is anticipated that deviation from this will likely take place in the near future since we are approaching the minimally adequate number of Apple machines for regular instruction. Pressure is already being felt to begin looking at other machines for various uses other than direct instruction.

4. Interactive video equipment has just newly arrived. Involvement in this field will begin soon but the direction to be taken in this area has yet to be decided. The use of interactive video may prove to be an area of application of computer technology as exciting for education as many say the microcomputer will be.

It is clear that the activities which have taken place in the past three years are the predecessors of many more activities in the future. These activities will involve many more persons than before as more faculty (and staff) become comfortable with the equipment. It is anticipated that this activity will accelerate, due in part to the faculty seminar and the increasing availability of equipment. This will necessitate greater coordination to minimize the duplication of activities.

Without a broad base of faculty support and familiarity with the field little integration of educational computing into the programs of the School of Education can be expected. Thus the philosophy to date has been to direct initial efforts for the incorporating microcomputers into the School of Education by the orientation of faculty and staff. We have succeeded in this thus far, however this has not been to the exclusion of other efforts, as can be seen by the above list of activities over the past three years. Increasing availability of equipment has allowed greater numbers of persons to become involved. With additional changes in technology, questions concerning the direction to be taken in the future will have to be addressed. Weighing these needs against a myriad of other demands on finances and personnel is a difficult process.

The School of Education of the University of Colorado-Boulder is in much the same position as schools elsewhere. We do feel, however, that we are ahead of others in getting the total faculty and staff involved. The nearly eighty percent participation in the faculty

seminar will and has caused faculty who would otherwise not be invovled to develop creative uses of these machines. In otner ways we are experiencing the same technological growing pains that others experience. We are fortunate to have a supportive administration at both the School and University levels. The question of what to do for the pre-service teacher education students is being addressed and action will be taken soon. We forsee that the next few years in education will be challenging and exciting because of the pressure of technological change. We see greatly increased activity in computing in education and plan to be leaders in this field.

COMPUTING AND EDUCATION AT TEACHERS COLLEGE

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This paper describes the computing and educational activities at Teachers College, Columbia University, in mid-1982. All the activities presuppose certain ideas and beliefs about computing, so these are outlined first. Individual activities and their mixture have been shaped by the tradition of Teachers College, so that tradition is briefly summarized next. Several illustrative activities are presented next, each in a separate, descriptively subtitled section of its own. The staff responsible for those activities and the facilities used are summarized next. The paper concludes with a look ahead.

Presuppositions about computing and education

Computing will expand the focus of educators to include far more attention to process. Though end products such as the problem's solution or the finished essay will remain important, computing will sharpen attention usefully upon how such products are produced, helping the learner to become more self-sufficient by helping her or him to understand and improve the process that creates the products.

Computing will raise graphics to a new level of importance, particularly when compared to text. Dynamic images and means to create, store and manipulate them will become as commonplace to future learners as parallel activities with text have been to preceding generations.

Computing will so permeate our lives that broad computing literacy will be absolutely essential. Those in education must help to develop that literacy, across the entire population.

Computing will permeate and inform the entire curriculum, even as (though for quite different reasons) theology did in medieval universities. It will no longer be seen as something for mathematicians only but will be used integrally from one end of the curriculum to the other, even by people who see themselves as "non-scientific" or "non-mathematical."

Computing will be used in many different modes within education, and none of these modes should be neglected by those seeking to improve education. Though "tutee" or discovery/exploration computing may be exciting and fulfilling in the right situation, excellent tutorial software will always have a valuable role to fulfill, as will other more tightly constrained software systems.

Programming and being able to program in several languages will remain a valuable background for anyone wishing to play a key role in the application of computing within education. Knowing what lies behind either a successful piece of software is critical in imagining the next step.

Evaluating and developing software are both essential skills for any one seriously applying computing to education. Extensive practice with each is indispensible.

Broader human issues, issues the self-proclaimed expert in computing and education and the vendor have no interest in nor time for, must be constantly considered and debated. Institutions with some mass must be among those who continually press ahead with examining such issues.

Technology needs imagination, and educational computing needs it as desparately as any technological activity we have ever engaged in. Literature, drama, art, music and other traditional activities must be continually re-experienced by those designing computers and computing software for education so that our technological creations stretch the mind rather than shrink it.

Teachers College, Columbia University

Teachers College is the graduate school of education associated with Columbia University. It enrolls more than 4000 students across three major divisions focussing respectively

upon psychology, health and nursing, and instructional institutions and programs. The activities of computing and education are housed within the division of instruction, a division which also houses the traditional instructional areas such as math education, science education, and music and art education, as well as such newer areas as TESOL and bilingual education. There are between forty and fifty students enrolled for degrees specifically in computing, mostly at the masters level. Undergraduate and graduate students in computer science are in a completely different part of the University and utilize separate computing facilities from those mentioned below as belonging to Teachers College.

During its near century of existence, Teachers College has had a major influence on education, both in this country and around the world. If there is one thing that characterizes that influence more than anything else, it is its breadth. Unlike other major private schools of education, Teachers College has tended to aim its programs, courses, and public proclamations at the mass of educators rather than the academically elite.

In computing, this is reflected in our attention to literacy, to broad programming skills, to a masters level program aimed at those without computer scientific skill, and to an attempt to develop materials and books that will be useful in educating a wide range of educators. It is also reflected in our attempts to incorporate computing into the entire curriculum, both in field projects and at the College itself. We believe the development of highly technical skills is best left to computer science colleagues; our job is to encourage them in the right directions, to creatively apply what they develop to education, and to make the mass of educators aware of the implications of the results.

As the College reaches its centenary, computing will be an increasingly integral part of all its academic activities. The concommittant transformation in what instruction means and how it is best carried on should be visible and intelligible to the average educator around the world.

Computing and education activities

Program/Department

In 1975 a modest masters degree program in computing and education was established at Teachers College (Taylor 1977). In 1981, it was merged with two older programs, Communications and Instructional Technology, to form the new Department of Communication, Computing, and Technology in Education.

The new department was formed because faculty and students in the three programs shared so many concerns and interests. They include: the effects of electronic mediation upon communication, the impact upon human communication of dynamic computer graphics, the meaning of the non-verbal forms of some computer activities such as arcade game playing, the implications for education of what MacCluhan dubbed the electronic "global village", and the relation between traditional skills in instructional design and programmed instruction and the development of computer-based software.

Degrees

Since 1975, the College has offered a popular masters degree (M.A.) in computing and education. It requires about 10 courses, five which must be from those listed in the section below subtitled Courses, and two which in turn must be Programming I and II. Apart from Programming I and II, the course selected by and approved for the student depend significantly on her or his undergraduate major, work experience, and career interests. A course usually meets an hour and forty minutes, once a week, for a term (13 to 15 weeks). In this program, it usually involves work on several computers, outside class, either independently or with partners in a lab. Most students are employed full-time somewhere in the New York metropolitan area, so all courses are scheduled in the evenings or on Saturday. The typical load is two courses per term, so it usually takes two years to complete a masters degree.

In the new department, students may also pursue a doctorate (Ed.D.) in either communication or technology, with a major in computing. (We expect to gain approval from the State of New York to offer such a degree, but labelled "computing and education", within the near future). In such programs, students must complete 90 points and a dissertation.

Though tailored to the individual, each doctoral student's program would normally include most of the 10 courses listed below, several courses from communication and technology, courses on test construction and curriculum development, psychology and other relevant areas, and from 10 to 20 points of independent study focussed on the dissertation. As

with other Ed.D. programs at Teachers College, up to 45 points can be granted for comparable level work done at another institution, provided the advisor approves it as relevant.

The dissertation need not be primarily a document like a Ph.D. thesis; it can be software or other computer related materials, accompanied by a relevant justification and appropriate documentation. We expect, for example, that the new course in software development will naturally lead to dissertations for some students.

Students are also expected to intern and assist, either in the Microcomputer Resource Center, in courses, in various field projects, or in combination of several of these activities.

Courses

The following are the ten computing courses now being offered in the department. The many offerings focussed more specifically on communication or instructional design are not shown, nor are seminars, colloquia, and internships common to the entire department.

Computing Literacy (2-4)
An overview of computers within society, particularly education. Demonstrations, readings, and hands-on participation introduce a wide range of computer applications and underlying concepts. Assumes no computing experience.

Programming I (3-4)
Communicating with computers and humans through programs. Uses FPL, a new language designed to clearly introduce fundamental programming concepts, and either BASIC or Pascal or both. For beginners or experienced programmers.

Computers and writing (3)
The use of computer text editing and processing systems in writing. Focuses on writing as a process, synthesizing psychological theory about writing with current computer capabilities. Assumes no computing experience.

Computers and the language arts (3)
Demonstrations, theoretical review and practical work with software for teaching reading, writing, grammar, and literature in English and other languages. Assumes no computing experience.

The computer as an instructional aid (3)
A range of computers are used to explore specific commercially available products and services that apply computing to instruction. Computer as tutor, tool, and tutee.

Programming II (3-4)
Prerequisite: Programming I. Extension of Programming I. Applies programming to significant problems through team programing projects.

Teaching computing (3)
Prerequisite: Programming II. Explores and practices pedagogically sound ways to teach computing and especially programming to a range of students, including those outside math and science. Includes limited teaching activities.

Computer graphics (3)
Prerequisite: Computing literacy, Programming I, or comparable introduction. Introduces basic types and applications of computer graphics, particularly but not exclusively in education. Explores various hardware and software systems, provides some hands-on experience, but not programming.

Software evaluation (3-6)
Permission required. Introduces a range of evaluative instruments and techniques and applies them, through student teams, to a number of representative, commercially-available instructional software programs and packages.

Software development (3-6) Permission required. Team approach to developing computer-based educational software in a variety of academic subjects. Complete modules and systems of software will be designed, programmed, tested and documented.

Developing methods and materials

Since a major problem in integrating computer education into teacher training is the lack of models to emulate, methods to adopt, and materials to utilize, we have tried to make our work serve not only our immediate program needs but also the needs of other schools

and departments of education as well. That is, we have tried to create materials that embody our developing methods and models, so that others may begin with more than we did.

The program in computing and education and the various courses are models that embody methods which can easily be copied or adapted by the many students who graduate. Certainly they will make use of some or all of them, thus avoiding some of the initial efforts we had to make. But those who never study here will not benefit very directly from such adoption. We therefore have published some of our materials so that a wider audience may profit from them. Two examples will illustrate.

FPL : A language for learning programming The language we use to teach teachers programming is FPL (First Programming Language). The language and the material reflect our assumption that most people will learn more than one language, and that the first one learned (especially by an adult) should be well structured, graphic, and simple. Accordingly, FPL is taught first but is linked to the learning of both BASIC and Pascal, in such a way that even the BASIC programs developed are well-structured and easy to read and maintain. FPL is simple, including only one graphic ikon or image for each of the foundation elements of classical programming. The language is presented as we use it in Programming I and II, including our work in both BASIC and Pascal, in the text, Programming Primer (Taylor 1982).

We have also developed a tutorial interpreter for FPL which greatly speeds of the learning of syntactic and definitional details of the language. Both book and interpreter assume that learning occurs most consistently from copying and modifying models and that the best materials take seriously the learner's point of view, providing help and explanation in enough detail to be useful to the novice, but in a form and location where they can be conveniently skipped over by the learner who does not need them. Though only available under test status now, the interpreter will be made publically available on several types of machines in due course.

Tutor, Tool, Tutee : A framework for grasping diversity To bring teachers more rapidly up to a position where they can wrestle with the educational implications of widespread integration of computing into education, we encourage them to use typologies, analogies, and other classificatory frameworks to categorize diverse examples of computer use in education.

Such an example is used in The Computer In The School (Taylor 1981). That book represents the whole field of computing and education by a collection of nineteen pioneering articles, and suggests a three category framework (computer as tutor, tool, and tutee) to simplify coming to terms with that diverse field.

By presenting several quite different types of educational computing and their implied presuppositions, this material make it difficult for a student to easily maintain too narrow a perspective on what educational computing is. At the same time, by the presentation of an appropriate framework, such material enables the student to superimpose enough order on the diversity to remain comfortable with its very breadth. Thus the learner can immediately assume a realistically broad outlook without feeling lost in the chaos.

Special conferences

Since by their general design, association conferences leave many relevant topics either totally unexplored or barely examined, we also sponsor specially focussed conferences from time to time. We hope these conferences, when they are any good, will also serve as models.

The conference on Child Appropriate Computing which we held in 1981 is a good example. It was designed to make vendor products the focus of conferee evaluation and thus to determine the extent to which hardware and software marketed as appropriate for children was actually appropriate or inappropriate for them. Ten vendors or developers came in and the one hundred conferees (all experienced computer using educators) were divided into ten teams of ten members each. Each team spent one day evaluating four of the products, each in a one hour session. Each vendor made an identical presentation four times during the day, to four different teams. The presentation could take any form the vendor or developer thought would best show off his or her product's child appropriateness. The evaluations were then written and pooled, and a closing discussion was held in which the evaluations and their import were summarized. By focussing on this topic and upon selected products, conferees and vendors alike got a deeper perspective on what was and what was not child appropriate about the products presented.

Software evaluation

A good bit of effort goes into systematic evaluation of instructional software at Teachers College. A funded project involving several micros and hindreds of hours of graduate student time continues to examine software and refine instruments and techniques for evaluating it. The EPIE (Educational Products Information Exchange) project regularly publishes its findings through channels it earlier established for disseminating reviews of text books and other non-computer-based instructional materials. The knowledge of the evaluators and the presence of the software are rich sources of information and material for staff and students in the program, not merely those few actually doing the EPIE evaluations.

Research

At Teachers College, both inside and outside the department principally concerned with computing, considerable research dealing with computing and education is in progress. Some concerns how adults learn programming, some how children learn both programming concepts and other ideas related to using computers, some what teachers need to know beyond a language such as LOGO if they are to use it effectively in a normal classroom, and so on. By far the most extended research activity in computing and education here now, though, concerns the use of computing in writing. Under several separate grants, we have been both developing a more appropriate text editor/writing prompter for children and studying how the use of computers in writing affects the quantity and quality of their writing (D'Aiute & Taylor 1981). We believe that a major impact of computing in schools will be to improve the learning of writing, and hope our work will provide useful materials in this area, too. (Both a book on computers and writing and the editor/prompter software are currently being readied for publication.)

Other departments at Teachers College are also beginning to conduct research into various aspects of using computers in education and that work can only be expected to increase in the immediate future.

Field work

At this time considerable assistance is being given to a number of school districts, primarily in terms of short term training delivered by graduate students, going out to the districts requesting such help. The scope of this work varies widely, from one visit to arrangements that span several years. The latter kind are the most useful in terms of providing more solid help to the districts and some steady (if minor) income to graduate students. Some of this work has been written up (Sobol & Taylor 1980) but most has not. We regard it as important not only for the help it offers districts but also for the research opportunities it may afford. Unfortunately, though some of our graduates are setting themselves up to do this sort of in-district training, there remains a shortage of people really qualified to do it here, just as in the rest of the country. Qualified people can make so much more money by applying their computing skills elsewhere, that few find this sort of work attractive for long.

Facilities and staff

Facilities

The computing activities here utilize the DEC20/60, the various micros in the Microcomputer Resource Center, and indirectly, the many micros people now have access to at home or at work.

Central Time-Sharing Computer Approximately 20 of the terminals directly connected to the DEC20/60 are available 24 hours a day, seven days a week on a first-come, first-serve basis to the several hundred students in various departments who make some consistent use of the computer. An additional 20 phone lines are also available, on the same terms, to those having access to a suitable dialup terminal. In addition to FPL, BASIC, and Pascal, several editors and a great variety of other software are available to students using this central time sharing system. Students in the program must use this system for some of their work even if they do most on one or more micros. We believe students should be familiar with both large and small systems.

Microcomputer Resource Center The MRC includes both micros and helpful humans and together they play an important role in many of our activities. There are currently about 20 machines there (the number varies with filed work assignments, repair returns, etc), of 6 different types (Apple, HP, Monroe, Pet, Radio Shack and TI) and a vast array of instructional software. The staff include a director and 5 to 10 graduate students, each of whom puts in a few hours a week. Some staff double as instructors in orientation and training scheduled for the MRC; some double as software evaluators in the on-going EPIE

software evaluation project. Most are familiar with several micros and a variety of software and thus can be usefully informative to students and teachers visiting the MRC.

Other facilities Because they are established in jobs, and increasing number of our students (not as many as we might wish, however) have access to one or more computers either at home, or at work, or both. We encourage them to use these computers if at all possible, both to lessen the load on our own facilities and to tie the computing of such students more closely to machines they will primarily use outside Teachers College. Because of the range of research going on, there are also a number of micros available on a more limited basis, to selected students, usually those connected with the research project to which the micro belongs. There are about 10 machines in this category now, mostly Apple II's.

Staff

The department has four professors, one of whom does nothing but computing and education, one of whom splits between instructional design and computing, one of whom spends a minor part of his time on computing, and one of whom spends full time in other areas of the department. In addition, the department has a full time instructor in computing and a number of part-time instructors who teach or assist with one course. There are two faculty members elsewhere in Teachers College who also spend most of their time on computing and education, one on the psychological implications of that computing, the other on administrative and management aspects of computing in schools and colleges. The department has a number of other adjuncts and instructors who are quite active in computing, typical examples being one in computing and writing and one in software evaluation.

Future directions

At this time, we see the future only dimly and only the near future at that. So far as Teachers College is concerned, we think that eventually courses in computing and history, computing and music, and so on will spring up and become part of the curriculum in each separate subject area, so they will not be housed except temporarily in the department or program of computing. At the same time, we think most schools and departments of education and teacher training will have separate programs or sub-departments specializing in computing in education. While it may be true that computing should be integrated into other subjects, computing is and will continue to be a subject in its own right as well. It has emerged as a politically separate entity within the university curriculum and is emerging as a separate entity in the school curriculum as well, particularly in the form of courses on programming.

We think the implications of extensive computer usage in schools will be an important focus of study for some time to come, particularly in terms of graphics, interactivity, modelling, process, and problem solving. As the routine aspects of computing in education become normal parts of the traditional methods courses and as people arrive already knowing how to program as well as is necessary, our attention will increasingly be focussed on what it all means. It may be that along with introducing artificial intelligence to schools, we may increase artificial ignorance. If so, we will have lots to think about.

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TEACHER EDUCATION CURRICULUM FOR THE 80'S

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Recall "The Saber Tooth Curriculum" -- a satire on education, authored by Peddiwell with a foreword by Harold Benjamin? This curriculum taught the students the fundamentals of fish-grabbing-with-bare-hands and saber-tooth- tiger-scaring-with-fire even after the tigers disappeared and fish nets were invented. Are we, in teacher training, caught up in supporting a curriculum which has been effective during the past five years but which may be totally inappropriate for the next five?

The other day two professors from a school of engineering were discussing the merits of certain programs within their department. One professor felt that the school's obligation was to put an engineer into the field who could function with the existing technology. The other professor felt that, since the technology would change before the student graduated, it didn't really matter what the student was taught as long as he/she possessed necessary learning skills. Five years hence, the student would still be an engineer only if he or she could keep up with fast changing developments in the field. To a certain degree, we who are in the profession of training classroom teachers are faced with a similar task.

It is clear that the computer will have a dramatic impact on the classroom during the 80's. A current survey conducted by the Oregon Department of Education has revealed that over 50% of Oregon's schools are now using computers for instruction. Minnesota alone has 20,000 microcomputers in 1800 secondary and elementary public schools. The State of Alaska has adopted telecomputing as an integral part of their statewide educational system. Alaskan school systems consider the microcomputer a standard instructional tool and teachers have readily accepted its presence. Pitka's Point, a remote rural school district of 37 students provides eight APPLE microcomputers for general instructional use. Anchorage, the largest district in the state, has a well defined and articulated computer curriculum serving all 73 schools with computer-assisted learning. From Alaska to Florida, shools are budgeting for microcomputer equipment and supplies. By 1984, it is expected that over one million microcomputers will have found their way into the nation's schools.

Today's freshman is tomorrow's beginning teacher. How can we prepare this teacher to cope with the existing technology and yet be equipped to face the demands of tomorrow's classroom? We have entered an era which will be known as the Communications Revolution. We must give the teacher entering this transition period the skills needed to survive the first few years in the traditional classroom and yet build a foundation of knowledge needed to cope with the developing technology.

Tomorrow's teacher must be an effective manager of learning rather than the principal source of knowledge. In tomorrow's classroom, through the use of telecommunications, the student will be able to call up information on almost any subject. Many of the files accessible to the student could be learning episodes on various topics. Accessibility to information will not be a problem, but for learning to take place, some structure needs to be imposed on the sequence of accessing this information. The computer can keep records on students' interaction with episodes, but the teacher needs to interpret the record's meaning. It will be the teacher's responsibility to work with the student and the information system to help the student maintain a reasonable learning pace. More of the teacher's time in the future will be taken up with the tasks involved in assessing, diagnosing, prescribing, directing, and managing the instructional process. Ways will have to found to help teachers manage the instructional environment more effectively if there is going to be time for the teacher to interact with students.

The microcomputer presents the teacher with the opportunity to individualize instruction. No matter what delivery systems are created, there are certain aspects of learning which must be considered. Living in a society where we are interdependent, students will still need to gather together to foster social interactions and to learn how to live in a supporting manner. An educational environment will have to exist that will allow students

to learn how to acquire and process information. Some areas such as mathematics, language arts and reading can be assimilated at the student's learning pace independent of the rate of the group to which they are attached.

What kind of skills must our teachers possess? Every teacher, in addition to having a basic subject matter competency, must be aware of subject matter resources and be trained in their evaluation. Every teacher must have some management training in order to effectively monitor students learning. The teacher must be able to organize and direct group activities. Finally, in order for the teacher to encourage students to progress on an independent basis, he/she must master the available technology to support the learning environments determined by student needs.

To meet these needs, the pre-service and in-service training must:

1. Educate teachers to be managers of information.
2. Prepare teachers to be leaders of group process.
3. Train teachers to diagnose and place students within a learning system in which the student can make progress.
4. Instruct teachers to operate the equipment that will be used to help deliver the content.

All learning environments that permit student advancement on an independent basis require elaborate record keeping systems for tracking students' progress. Most future systems will be computer controlled so that record keeping does not impede a student's movement toward a defined goal. Within the next ten years students will no longer be dependent upon the teacher to begin a lesson. Students will be able to engage in a dialogue with the computer which will help them advance in fundamental skill development at a rate that is not possible within today's classroom. The teacher should understand the technology of such systems in order to maximize his/her effectiveness. How should the teacher training curriculum reflect the needs of this learning manager? Future teachers need to be involved with computer based education throughout their college experience. Appropriate preparation includes a lower division computer literacy course and a series of involvements with the microcomputers within other courses.

CS 101 Computers and Society is in the process of being required of all students at WESTERN OREGON STATE COLLEGE (WOSC). This course emphasizes an understanding of computer based technology. The student is required to demonstrate an ability to interact with microcomputers and run application software. The student is expected to explore the impact of the computer on society. The student is required to write reports on the above activities and is expected to use the microcomputer as a tool to accomplish this task.

The computer should be used as a learning tool within the student's college classes. Students need to experience how one learns via the computer. At WOSC we are in our third year of a National Science Foundation - Comprehensive Assistance to Undergraduate Science Education (CAUSE) grant titled "Infusion of Computer Science into Liberal Arts and Teacher Education". One component of this grant is the training of ten faculty members per year concerning the potential of the computer as an educational tool. This is accomplished through a two week summer workshop during which time the faculty member defines a project to be implemented during the course of the following year with grant support. Through these activites we have begun to incorporate the computer as a teaching tool in several courses in various departments on campus. The most successful applications to-date have been in the Music, Dance, English Composition, Biology, Mathematics, Education, and Psychology areas.

First Year CAUSE Projects:

Special Education/Psychology - computer-aided testing, software programs for lab experiences, and student scoring of their own personality inventories.

Music - pitch and interval ear training and multi-voice score training.

Physics - wave motion demonstration program.

Mathematics - Intermediate Algebra competencies and data research on testing.

Chemistry - organic compounds nomenclature practice.

English - composition editing using word processing.

Education - application of on-line computer-administered testing.

Second Year CAUSE Projects:

Psychology/Special Education - statistical teaching packaged.

Economics/Business - record keeping system, simulations of running a profitable business, and fiscal management.

Biology - use of pre-packaged programs in General Biology and demonstration of various programs to elementary teachers.

Mathematics - graphing programs for trigonometry and college algebra and elementary school students.

Dance - video-computer interface on ballet movements and vocabularly.

Education - collection and analysis of student data and transfer of that data to a statistical package.

For the education majors, additional training is required to lay the foundation for using computers as an instructional tool. Very few instructors write primary textbook materials, yet almost all instructors create supplementary materials. Similarly, the typical classroom instructor will not be writing computer programs, but will be creating or managing supplementary materials.

The focus is on helping the instructors learn to choose and use good application software in their classroom and to use the computer as a management tool. The following topics are covered in the foundation block for elementary and secondary education:

1. Computer managed records
    a. Grade book
    b. Test banks of questions
    c. Achievement records
2. Drill and practice material
3. Tutorials
4. Entire curriculum packages
5. Video/computer interface
6. The computer as an exploratory tool
7. Software evaluation and selection.

For students who wish to develop a computer science emphasis the following courses are available at WOSC.

First Year:

CS 101	Computers and Society	4 credits
CS 133	Computer Coding - BASIC	4 credits

Second Year:

CS 211	Introduction to Computer Science	4 credits
CS 212	Techniques of Programming - PASCAL	4 credits
CS 215	Computer Organization (Assembly)	4 credits
CS 213	Symbolic Language - FORTRAN	4 credits
CS 217	Intro to Data Processing - COBOL	4 credits

Third Year

CS 311	Symbolic Language Programming	3 credits
CS 371	Applications Programming I	3 credits
CS 372	Applications Programming II	3 credits

Fourth Year

CS 430	Data Structures and Management	3 credits
CS 406g	Special Topics	3 to 4 credits
MTH 406g	Extended BASIC	4 credits

Students who wish to become the managers and area specialists on computers within schools need to have much of the same basic training as any other computer science person at the lower division level. Their upper division work should be directed toward the area of teaching about computers or the development of instructional material. To provide for this need WOSC offers the following courses.

ED 451g Microcomputer Systems 3 credits

The building of a working vocabulary dealing with microcomputers. Essential hardware and software components and their functions are studied. Applications of microcomputer systems within the classroom are investigated.

ED 452g Computer Based Education 3 credits

Characteristics of computer-based education illustrating the advantages to be derived from using computer-managed and computer-assisted interactive systems. Most of the work in the class will be focused on the microcomputer. Prior classwork in ED 451g and/or CS 133 is required.

ED 461g Computer-Assisted Instruction 3 credits

The design of computer-assisted instruction lessons and interactive systems will be studied. Students will be asked to design a set of computer-assisted lessons for classroom use.

ED 466g Computer-Managed Instruction 3 credits

This course is designed to introduce students to a computerized method of testing, record keeping, and decision making that will assist administrative, classroom, and individual learner management. The student examines how computer-managed instruction can solve the management problems of individualized instruction.

A revised educational technology masters degree program incorporating up to 18 credit hours in computer application courses has received committee approval and is in the process of being implemented.

Supporting our underlying philosophy that the computer is an instructional medium available to all students, WOSC has one central facility consisting of 13 APPLE II microcomputers, 10 of which are connected to two CORVUS hard disk drives. Two of the systems have printers attached to them. In addition there are three free standing units, one of which has a video interface. This facility is located in the college library providing access to all. There are also six microcomputers located around campus for faculty development of programs and classroom demonstration. During the course of the school year over 50% of the college population interacts with these computers.

The CAUSE Grant has allowed us, at Western Oregon State College, to begin acquainting faculty and administrators with microcomputers. The faculty has begun to examine the curriculum to see how to make use of computers as a teaching tool and to determine the degree of exposure a beginning teacher needs to be prepared for tomorrow's classroom.

Realizing that public education is in a period of dramatic change, we believe that all aspects of teacher education must be examined to insure that we can help future teachers not only gain skills in working with people but also gain the skills needed to use the developing educational technology. Curriculum must be continually examined and adjusted or teacher education risks being out of phase with both students and society itself.

Computers for teachers
Activities at the University of Michigan School of Education

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In this report we describe the present status and future plans for computer-related activities at the School of Education (academic programs, service, research, and facilities). Also we hope to convey something of our approach (e.g., emphasizing school and community resources) and our ideas about helping teachers with computers in schools (e.g., encouraging action-oriented research). The views expressed are those of the authors ("we" = Berger and Zinn) but many of the ideas are from others in our research collaborative for computers in education (Arthur Coxford, Robert Dixon, Fred Goodman, and Robert Kozma) and the resource center (Peggy Schmidt and Beth Miller). All contribute to the planning, research, teaching and service.

Introduction

Before listing some of the things being done (and being planned) for teachers using the resources of the School of Education at the University of Michigan we should describe the basis for our interest in and approach to serving education through computers. In general, we strive for balance among teaching, research and service; we hope to develop, apply and share knowledge about the use of computers at all levels of education, elementary school through college. We choose to give special attention to school and community resources, and then make the most of the special resources of the University of Michigan and the School of Education.

Focus on school and community resources. The things most important to effective learning with computers are happening today in schools and homes, not in universities and colleges. What we do for teachers using the resources of the School of Education must serve them well in their own schools and communities. Therefore the preservice training, as well as inservice programs and consultation, is carried out with an eye for the facilities and situations which will be found in the local schools.

Computers, education, and teachers. Inexpensive computing facilities that are easy to use will be one of the more important things to happen to education in this century. We believe that the experience of teachers and the availability of technical support will be the most important factor in determining how well computers are used in schools. The need is now, and growing more rapidly than institutions and professional organizations can respond.

A role for schools of education. Colleges and universities can translate interest in computers and education into actions to meet the needs of students, teachers and administrators by going out into the schools and communities to assist with operational programs, by maintaining high standards for professional development and practice, and by nurturing appropriate interest in research, e.g., to increase knowledge about teaching and learning processes. More specifically, we recommend that schools of education provide practitioners with skills in teaching and administration of computer-related curriculum as well as information about computers, and arrange for continuing support of on-going programs as well as one-shot training to get them started. Action-oriented research is appropriately included in all training and support activities, that is, professionals should get involved in planning for, collecting and interpreting data to aid in decisions in their schools.

Resources of the colleges and universities. Training and support offered to teachers through colleges and universities should take advantage of the special resources available there. Microcomputers are used throughout the University in many different ways: information systems, process control, laboratory equipment, specialized graphics, etc.

Students have a unique opportunity to learn about current and future uses of microcomputers, and as teachers they need to know about computing in their subject areas, in jobs, and in society, not just in the classroom. Exploration of microcomputer applications opens doorways onto the entire world of computing.

The University of Michigan has been a leader in computers and education since a Ford Foundation grant in 1956 for curriculum development in engineering education. Nearly all parts of the University have been involved, humanities and the arts as well as sciences and professions. Various units provide courses as well as new software and applications. Research and development throughout the University contributes to the quality of the program in the School of Education, and education faculty help other units using computers in teaching give appropriate attention to matters of learning and teaching. We believe the most effective uses of computers in education today are well based in the subjects taught and in the supporting disciplines, so we do not treat "computers in education" as a separate discipline.

Overview of this report. The first section describes the academic programs in the School of Education: degree programs, courses, independent work, and cooperation with other teaching units. The second and third sections summarize service and research activities. The facilities for educational computing are described briefly in the last section, and we close with a brief statement about future directions.

ACADEMIC PROGRAMS

Graduate degree programs with specialization in computers

The University of Michigan School of Education is organized in five large units: administration and policy planning; development, learning and teaching; higher and adult education; kinesthology; and speech and hearing science. Computers are used in all the programs, but they get particular attention in "development, learning and teaching" as part of literacy (along with language, math and science). Special topics such as problem solving, learning strategies and social relations are considered in all four areas of literacy.

Computing in education is not treated as a separate degree program because the University gives only one masters degree or doctorate in education, and, more importantly, because computing in education is considered in context (curriculum, learning, teaching, administration, policy, etc.) rather than as a separate subject.

Courses specific to microcomputers in education

Microcomputers and Education provides an overview of computers in education with special attention to instructional design, testing and evaluation. Microcomputer Programming for Educators serves as an introduction as well but leads to specific skills in one or more languages and the development of specific programs for use in ones teaching. These two courses are offered every term (including summer) and enroll about 30 students each time.

Microcomputers in the Classroom intergrates programming, instructional design and classroom management. Seminar in the Use of Microcomputers in Education provides for advanced project work. These two courses are scheduled once each year and restricted to graduate students; typical enrollment is 20.

Special topics for independent reading and research

Because the field is growing and changing more rapidly than a school of education can respond with new courses, and because the students learning about computers in education come from varying backgrounds and situations, the College offers many opportunities for study of special topics by individuals and small groups in addition to regular courses. Typically students will define topics for independent reading or research, often derived from questions raised during one of the regular courses, and sometimes based on experiences in their own teaching, research or administration (for those graduate student already working in schools). One or more faculty members will assist in redefining the topic and identifying resources for independent work. The results often are reported through informal seminars as well as in publishable reports. About ten students use this option each year.

These opportunities for independent work provide some of the flexibility needed in a

new area of study, and help detemine what topics later students should study as a more formal program is developed. That is, some of the following topics may become regular courses:

Computer use in science, math, social studies, etc.
Planning and administration of computer labs and programs
Curriculum changes due to technology
Information sciences and education
Social implications of technology
State and regional programs for computers in education
Learning theories and technology
Research and evaluation

Practicum or project experience

The need for practitioners helping with computer applications and studies in schools is considerable and immediate. The linkage between research and practice is of immediate benefit to operational programs as well as long-term research. Therefore, practical experience is very appropriate in graduate study of computers in education. We encourage practicums and project experience, either in association with on-going projects in the School of Education or elsewhere in the University, or in the schools in which the candidates presently work. We know no better "examination" than that provided by experience in the field: managing a microcomputer lab, developing instructional applications in one's discipline, or helping teachers to use computers more effectively in their classrooms. We expect about ten students a year to enroll for credit in a practicum; presently the only students in this category are working on doctoral dissertations.

Contributions to undergraduate courses

Undergraduates in our teacher preparation program have ample opportunity to use computers in their regular classes or independent work. In addition to trying computer applications in the relevant discipline, students are likely to be assigned other interesting activities, such as using a microcomputer to carry out a readability analysis of text materials (in a methods class) and designing a computer-based learning activity (in an educational psychology class). A microcomputer resource center provides machines, software, publications, and other materials for individual work, as well as an opportunity to observe learners from pre-school to adult working with computers individually or in classes.

Diffusion of computing through methods classes began with a grant from the "faculty development fund" at the Center for Research on Learning and Teaching. We went to the instructors with suggestions for computer use in the various disciplines, demonstrated the applications, and offered to assist. Virtually all methods courses now include computing activity directed by the individual instructors, with technical assistance from the staff of the resource center. Students can go on to teach themselves more about computers; some enroll in the undergraduate classes.

Cooperation with other teaching units

The School of Education draws on the resources of other units that work with computers and information systems, and also coordinates its efforts with others interested in computers in schools. The School of Library Science shares resources for demonstration and research (computers, computer terminals, teaching staff, and a special classroom); working together, education and library science prepare students for serving a support function in the schools. The College of Engineering has set up microcomputer classrooms (e.g., twelve Apples on a Corvus disk system in one lab, eight TRS-80's in another, and 60 IBM personal computers on order for a third) for undergraduate courses in programming and applications. At scheduled times these classrooms are available for demonstrations, workshops and special classes. The PET Shop (a room filled with 30 PET's for use in support of chemistry lab activities) is available for other uses, especially for summer institutes since only a few chemistry lab sections are scheduled in the summer.

The Department of Computer and Communication Sciences helps staff several courses off campus for teachers needing a sound basis in computer science. The Department of Psychology has several laboratories working on learning and instruction using computers, providing graduate students in education access to a wider variety of research opportunities. The Center for Research on Learning and Teaching helps provide the

resources for demonstration and research (computers, group viewing facilities, software, publications, etc.) and in return the School of Education helps faculty elsewhere in the University explore computer applications in their own teaching and scholarly work, a task beyond the resources of the Center.

The communication among faculty using computers began with a series of workshops and "faculty seminars" organized by the Center for Research on Learning and Teaching. Later the same series was offered on the site of the resource center in the School of Education, establishing it as the new site of information and advice. The Apple users group meets regularly at the School of Education, further identifying the resource center as a focal point for communication.

The cooperation among units has been formalized as the Instructional Technology Research Lab, a collection of people and equipment distributed among various units: Center for Research on Learning and Teaching, Education, Engineering, media resources, and liberal arts. Through this assocaition equipment and expertise can be assembled for research or service projects.

SERVICE

In-service training and related services

The School of Education offers many lectures, demonstrations and consultation on the use of microcomputers for schools. These include:

faculty orientation sessions;
intermediate district or county school board sessions; and
community meetings.

At times faculty members help staff the planning of computer systems and curriculum to be used throughout a school or district. We are always conscious of helping share experience among organizations and agencies. For example, we helped establish a state task force on computers in schools, we work with regional resource centers in the public schools systems throughout the state, and, of course, we share software through professional associations and user groups.

The University also offers specific inservice programs for school systems. These are scheduled for the conveneince of those served (workshops on Saturday; and extension courses in the late afternoon, on Saturday, and in the summer) and may include additional services such as:

consultation for individuals and departments
short-term loan of equipment
advice on special education facilities
information on computers and careers
resources for meeting special student needs
assistance with microcomputers in classroom management
training in use of various programming languages
advice on word processing and record keeping
development of microcomputer user groups

Because of the immediate needs of schools, teachers and students we do as much as we can to provide information and assistance with operational programs. For example, we offer advice and references for:

fund raising
equipment acquisition
clubs
field trips
public library programs
drop-in centers
curriculum libraries and program exchange
electronic bulletin boards and "conferences"
science fair projects
parent-child courses
coordination of home and school uses of computers
newsletter and other publications
radio broadcasts, cable programs, newspaper, etc.

RESEARCH

Research in progress and under consideration

Researchers at the University are active in a variety of studies and plan a comprehensive research program on the use of computers in education. A microcomputer research collaborative established in the summer of 1979 has encouraged and participated in research on: attitudes and values; learning with computer assistance; social structures (school, community, home); and futures. CAI (computer-assisted instruction) per se is not given much attention, but the researchers focus instead on aspects of learning (including motivation), procedures for curriculum design, social context for learning, or other disciplines which contribute to effective use of computers in education.

The realities of computer use in schools for the next few years dominate research planning. For example, attention is being given to conceptualizing how a single microcomputer is best used with a group of students where the institution cannot afford enough machines for everyone individually or in pairs. The program of research assumes more computers will be purchased for homes than for schools and so explores ways to exploit home computing for education.

Research is encouraged in many innovative uses of computers in education. Such uses include but are not limited to:

Attitudes that those using computers in education have toward:
- learning
- careers
- educational institutions
- technology in education
- lifelong learning
- creative activities supported by technology
- family activities

Learning with computer assistance, including aspects of:
- efficiency
- effectiveness
- long-term effects
- thinking and problem sovling
- learning skills
- skills for handling information

Social structure, involving:
- classroom structure and activities
- friendships
- interpersonal relations
- teacher-student relationships
- teacher role
- parent role
- implications for family

Futures research, including:
- anticipating new technology and its impacts
- assessing social implications
- shaping alternative futures

FACILITIES

Computer education resource center in the School of Education

The computer education resource center is housed in the Instructional Strategy Services unit of the School of Education, providing an appropriate context, technical support, and ready access for students, faculty and the teaching community to explore a new technology in education. Other programs of the Service unit provide links with graphics, video, curriculum review, information services, and the like. Of course, other units in the School of Education also use microcomputers in their work; students use machines in the Statistical Laboratory, the Center for Evaluation Research Training, and a special program in education and psychology.

Both the manager and assistant manager of the resource center know the computer field well, along with their own specialities in library science. Workshops, demonstrations, and open access fit well within its domain, and the unit provides the larger context of teaching and learning.

Equipment. The lab includes at least one of each common microcomputer along with documentation and a library of applications. About seven Pet's, ten Apples, and a dozen Atari's can be assembled so that workshops and classes have one computer station for each of two participants. Most of the microcomputers can be used as terminals on timesharing systems, and one additional terminal is dedicated to special uses in graphics. (These are in addition to the microcomputers and terminals in the nearby statistics lab for use by graduate students primarily in research.) Typically half of the machines are out in faculty offices or field research.

The equipment kept in the resource center is arranged about the periphery of the space for individual work but it can easily be shifted for group use or classroom demonstration. A second classroom is used when we call in extra machines. Group viewing is accomodated through use of large monitors: black and while monitors for applications which are primarily text, and color where that is helpful to the demonstration. The same monitors are used for viewing material from videotape or disc, indeed, some demonstrations have been put on videotape for more convenient use in group demonstrations as well as easy access by individuals. The resource center also has two videodisc players, one consumer model and one industrial, for experiments with computer-controlled videodisc.

Repair facilities. The staff person who handles other equipment for the Resource Center also takes care of computer connectors, cables, and the like. Some time is required for the cleaning and repair of disk and cassette media, the diagnosis of equipment problems, and minor repairs. This person also makes arrangements for outside repair as needed.

Materials. The computer lab maintains a large set of materials in cooperation with the Center for Research on Learning and Teaching. (Thanks to donations from faculty members and review copies from some of the publishers, most of the rather limited School funds are available for hiring students as assistants in the lab.) The center manages to maintain:

- a comprehensive program library (about 2000 items)
- a substantial reference library (about 150 volumes)
- most of the relevant periodicals (about 40 subscriptions)
- manuals for each of the machines
- most of the recent textbooks (about 40)
- media (self-instruction) materials
  - video tape (about 10)
  - tape-slide (about 20)
  - computer programs (about 30)
- annotations on programs and applications (done locally)
- self-help posters (done by resource center staff and students)

Staffing. The resource center is supervised by experienced library and media staff. The manager, assistant manager and laboratory aides together provide service to both faculty and students: comparison of equipment options; identification and review of software; advice on development of applications; and assistance with preparation of graphics for use in papers and other presentations. That is, the resource center provides computer resources for any scholarly work by students, as well as a site for study of computers in education.

In addition to the regular staff and faculty, undergraduates are hired as aides and programmers to extend the support staff to serve more people at modest cost. At the same time, the students use their work as a learning experience. About twenty undergraduate students benefit from this opprotunity each term. Graduate students help with review of application programs and publications. Workshops, short courses and program review are carried on by faculty members on a regular basis.

Uses outside regular instruction. Sevices to other units, organizations and informal groups have proved mutually beneficial. For example, the University of Michigan Apple users group meets regularly, and typically some education students who happened by, get "hooked" and leave with some new ideas or software for innovation or use.

Graduate students have gained excellent experience staffing special courses for the University Childrens Center, and education classes have observed young children exploring computers. The resource center is a resource for local teachers, providing the full range of information and examples maintained for University students and faculty, and offering demonstrations in an "open house" format and instruction through institutes and workshops. In addition, an academic program for talented students offered by the Gifted Students Institute each summer since 1978 provides one example of the "computer camp" idea that has become so popular recently.

Future directions

As more faculty, teachers and students get involved in the collaborative work on computers and education in the School of Education and throughout the University of Michigan, the range of activities and interests will increase. The directions taken by the School will be determined by the interests and energy of those involved. If our assumptions about current needs and requirements are correct, we will see continued emphasis on the role of school and community resources, careful study of the contributions of informal and non-traditional learning situations, thoughtful consideration of social implications of increased dependence on new technologies, and increasing collaboration among researchers in different units of the University. We also have a contribution to make to new models for planning and cooperation involving government (local, state and federal), education (elementary, secondary, and college; private as well as public) and industry (manufacturers, publishers, employers, and other beneficiaries).

The University of Michigan School of Education will expand its involvement with the use of computers in education many times over during the next few years. New technologies will be explored, for example, we have begun work with computer-controlled videodisc and personal computer networks. But more important, we plan to emphasize action-oriented research programs for teachers and students not only in Michigan but throughout the United States.